COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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July 1952

More Power for Israel

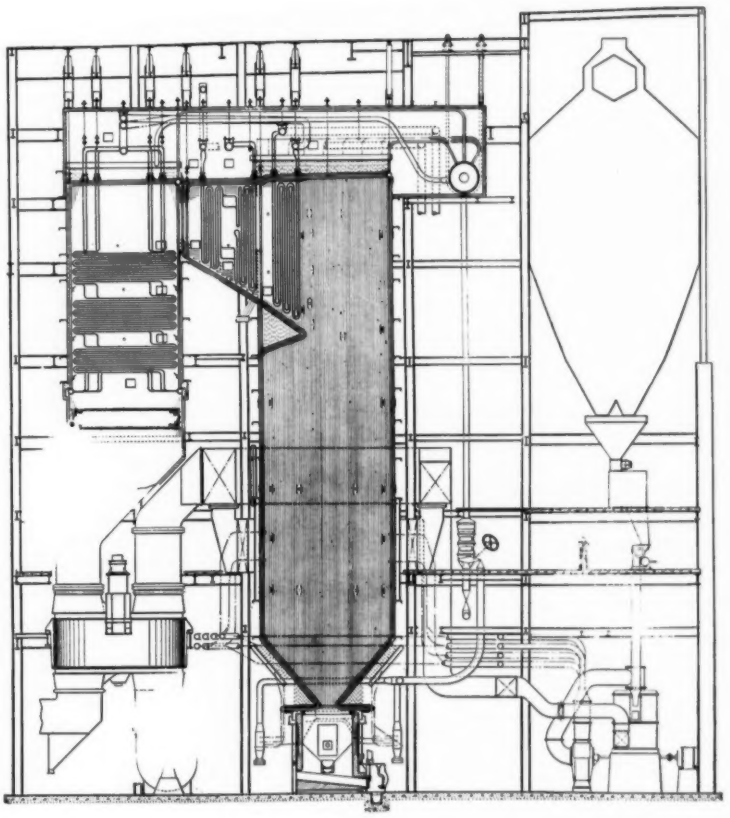
New Italian Power Station Operates at 1850 psig ▸

Relation of Spreader Stokers to Air Pollution ▸

EASTLAKE PLANT

The Cleveland Electric Illuminating Company

C-E controlled circulation boilers



The C-E Unit shown above is one of three duplicates now in process of fabrication for the Eastlake Plant of The Cleveland Electric Illuminating Company of Cleveland, Ohio.

Each of the three units is designed to serve a 125,000 kw turbine-generator operating at a throttle pressure of 1800 psi with a primary steam temperature of 1050 F, reheated to 1000 F.

These units are of the controlled-circulation, radiant type with a reheater section located between the primary and secondary superheater surfaces. An economizer section follows the rear superheater section and regenerative type air heaters follow the economizer surface.

Pulverized coal firing is employed, using bowl mills and tilting, tangential burners.

C-E

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200 Madison Avenue, New York 16, N. Y.

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COMBUSTION

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Vol. 24 **No. 1**

July 1952

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COPES *Applied to Hydraulic Couplings*

GIVES PRECISE FEED AND LEVEL CONTROL

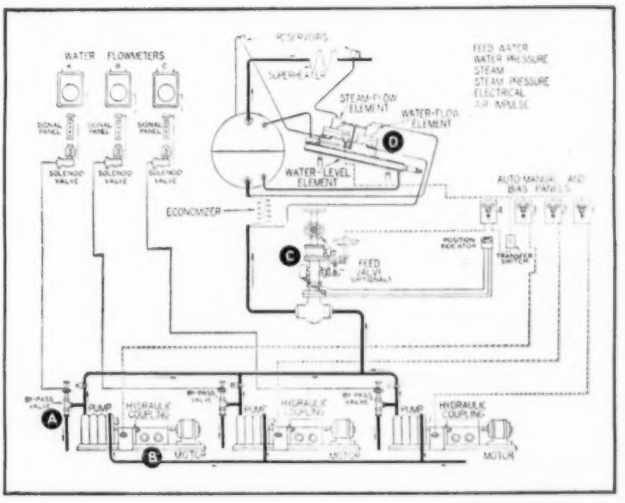
at PLANT YATES *of* GEORGIA POWER COMPANY

Remarkably close feed-flow and water-level control is being demonstrated daily by the COPES Balanced Flow Control at Plant Yates of Georgia Power Company, Newnan, Georgia. Units 1 and 2 went into service late in 1950.

Each unit includes a 3-drum, dry-bottom, radiant-type Combustion Engineering-Superheater boiler designed for a maximum continuous rating of 975,000 pounds per hour. Loads have been carried as high as 1,050,000—as low as 250,000—pounds per hour.

The COPES Control, applied through the hydraulic couplings of the feed pumps, matches feed flow almost perfectly to steam flow, and stabilizes water level within plus-or-minus one inch. Independent of meters and other controls, it can remain on full-automatic when they must be out of service for any reason. Duplicating COPES Control is on order for Unit 3, scheduled to start operation next winter. For complete data on COPES Balanced Flow at this utility write for Bulletin No. 489.

COPES-VULCAN DIVISION
CONTINENTAL FOUNDRY & MACHINE COMPANY
ERIE, PENNSYLVANIA

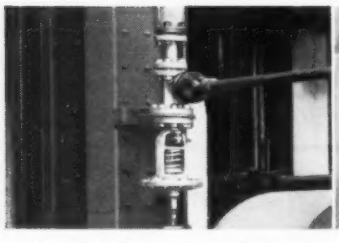


Schematic shows COPES Balanced Flow Control installed for each boiler at Plant Yates. Responsive to three influences—steam flow, feed flow and water level—COPES applies air impulses to position individual controller for the hydraulic coupling of each motor driven pump. Two pumps are normally paralleled, with third on standby, but any pump can be cut in or out by pushing the button to start or stop its motor.

Feed valve is normally wide open, but can be cut into automatic service at any time.

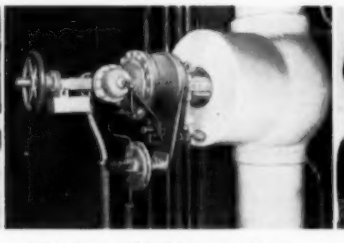
COPES Minimum Flow Control protects the pumps against overheating on light loads.

Headquarters for **Feed Water Regulators • Pump Governors • Differential Valves • Level Controls • Hi-Low Alarms • Reducing Valves • Desuperheaters**

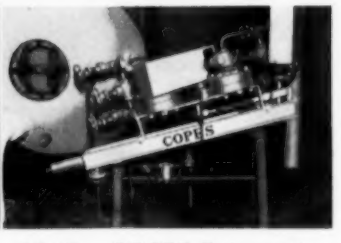


(A) COPES Recirculating Valve used with the Minimum Flow Control System to protect the pumps on light loads.

(B) Air impulses from the COPES Balanced Flow Control actuate this controller on the hydraulic coupling to control the speed of each boiler feed pump.



(C) The COPES Feed Valve, installed in a vertical line, is normally wide open but may quickly be placed on fully-automatic, if and when this is desired.



(D) The COPES Balanced Flow Thermostat has steam-flow and water-level elements mounted rigidly on the frame of the water-level element. It is rugged.

COPES **BOILER FEED WATER REGULATION**

Editorials

Restricted Information

As we are about to go to press, newspaper headlines proclaim a new transatlantic record established on her maiden voyage by the new liner *United States*. While the known distance and elapsed time permits checking of the average speed, reported the horsepower by which this speed was attained appears to be a carefully guarded secret, despite the fact that many of the other essential data covering physical characteristics of the ship have been released.

Granted that construction of the vessel was heavily subsidized by the Government and that the designers were required to meet certain requirements, since the *United States* is a potential high-speed troop carrier, just as were the British *Queens* during the last war, it would seem that such items as speed, size, tonnage, carrying capacity, etc., might more logically be regarded as restricted information than horsepower or steam conditions.

Perhaps this is just another example of bureaucracy ruling similar to that encountered during the last war, which forebade identification of power stations by name or exact location, although Government maps showing location of central power stations and transmission lines were obtainable through the office of the Superintendent of Documents.

In Recognition of "Extraordinary Efficiency"

There appeared in *The New York Times* of Sunday, June 22, 1952, an editorial entitled "St. Lawrence Quietus" which commented on the action of the Senate in sending back to its Foreign Relations Committee the bill that would authorize United States participation in the development of the St. Lawrence seaway and power project. Included was this significant paragraph:

"No one denies that New York State needs more electric power, but the need will not be met by the St. Lawrence. Nor will the argument that we must have the St. Lawrence plant to carry out our defense program stand scrutiny. By 1960 the demand for additional electric power in the state will be between three and four million kilowatts, of which two million can be met by further encroachment on Niagara Falls and by the proposed St. Lawrence plant. The balance of a million kilowatts and more must come from steam stations, which are now operated with extraordinary efficiency. There is no technical or economic reason why the St. Lawrence power plant should not be built, but the cold fact should be faced that its contribution to a Northeast power pool, about which the President has been talking, can be of no marked significance."

To remove from context a section of an editorial may result in misinterpretation of the original intention of its writer. But here is an instance in which the specialized field covered by this publication has received a bit of an accolade from one of the world's truly great newspapers. Apart from the international political aspects of the St. Lawrence seaway and power project, appropriate recognition is made of the fact that power generated by steam turbines may complement, rather than compete with, that generated through hydraulic turbines. In other words, the electrical energy must be provided eventually, and to this end all available hydro and thermal resources must be brought to bear.

Important, too, is the recognition of the "extraordinary efficiency" of steam power stations. This is a combined accomplishment of the public utility industry, the engineering consultants, and the manufacturers of power plant equipment. Continual reiteration of these technical advances and their effects upon power costs should be made so that the general public can understand and recognize the successful efforts of the engineers who made this technological achievement possible.

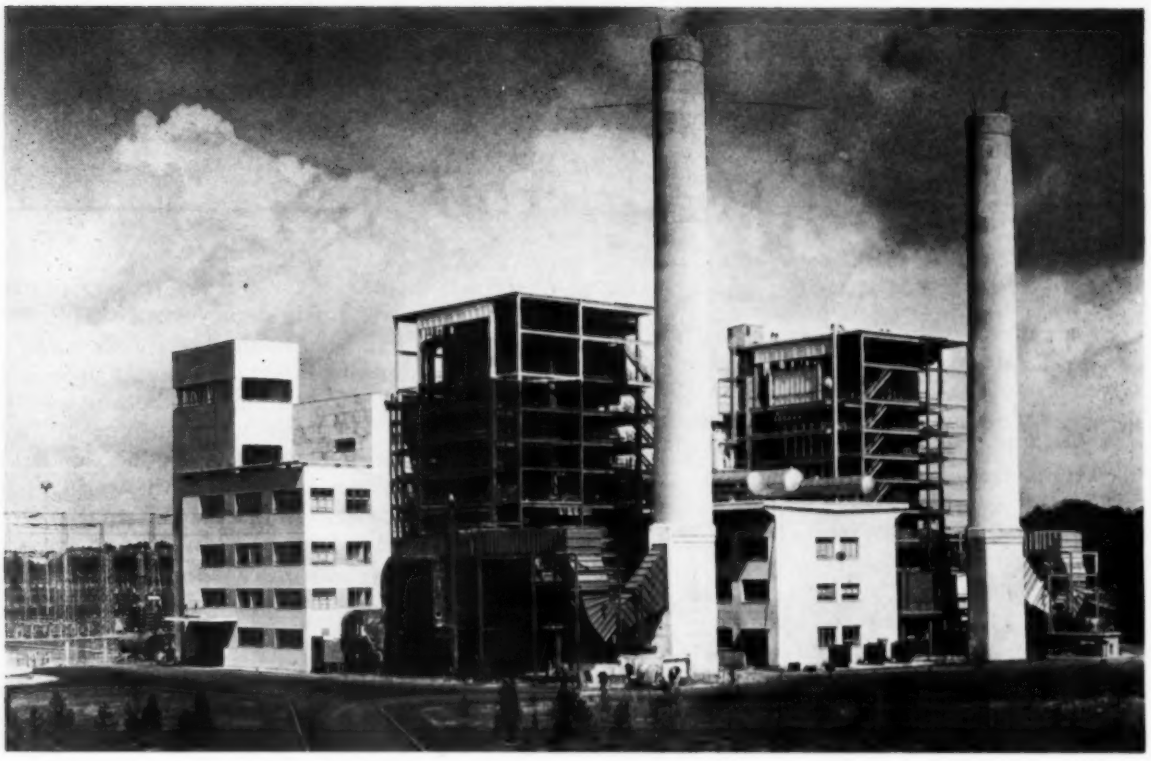
Tavazzano Recalls an Historic Event

The new Tavazzano power station, which was dedicated on June first in the presence of Italy's political and industrial leaders, including Premier De Gasperi, marked an important milestone in the economic history of that country, since it is independent of imported fuels.

As pointed out in the description elsewhere in this issue, it will burn natural gas from recently developed wells in the Po Valley, and because of its advanced design it is expected to show outstanding performance.

It is most fitting that this up-to-date station should be constructed near Milan where the world's second, or Europe's first, central power station was installed by Thomas Edison and started up only a few months after his historic Pearl Street Station in New York went into operation in September 1882. As in the case of the early station, it has been the privilege of some American manufacturers to have a part in equipping Tavazzano.

For his cooperation in expediting and checking our condensation of Dr. Castellani's article on Tavazzano, COMBUSTION is indebted to Valerio Havas, New York consulting engineer, who did the liaison work with the American equipment manufacturers and who recently returned from a visit to the new station.



View of Tavazzano Station showing outdoor boilers

New Italian Power Station Operates at 1850 Psig

The Tavazzano Station, near Milan, is not only the highest pressure steam plant in Italy but the first plant to employ natural gas as fuel. It has 125,000 kw capacity and is of semi-outdoor construction. Before entering the boiler furnaces the gas is passed through a turbine and the pressure drop utilized to produce useful power.

By DR. CLAUDIO CASTELLANI

Central Director in Charge of Power Services, Montecatini Corporation

SEVERAL "firsts," as regards Italian power plant practice, are embodied in the new Tavazzano Power Station, near Milan, which was dedicated on June first. It is the first Italian steam plant to employ natural gas as fuel; the first to have outdoor boilers; and the first to operate at 1850 psig, 970 F.

The installation was initiated jointly in 1949 by the Montecatini Corporation, Italy's foremost chemical combine, and the A.G.I.P. through formation of the Società Termo Elettrica Italiana (S.T.E.I.) which decided to construct a station of 125,000 kw total capacity. Later the Municipal Power Company of Milan, the Italian Edison Company and the Falck Steel Mills joined the S.T.E.I. so that each of the five companies owns 20 per cent of the stock. The planning, engineering, design, purchasing and testing of all materials and equipment, together with supervision of construction, was entrusted to the power division of Montecatini Company. E.R.P. funds financed only that part of the plant involving equipment which European manufacturers were not in a position to supply.

Dr. Claudio Castellani

Located in the industrial heart of the country, the plant will burn natural gas from the newly developed nearby

gas wells at Cornegliano in the Po Valley, about four miles distant, where there is sufficient margin between estimated supply and anticipated gas demand in this area to assure adequate gas for a minimum of fifteen years. During periods of low station load the surplus gas will be diverted to the network of gas lines connecting various gas fields in the Po Valley, whereas this network will provide a reserve gas supply for the station. The boilers are also equipped to burn fuel oil if necessary.

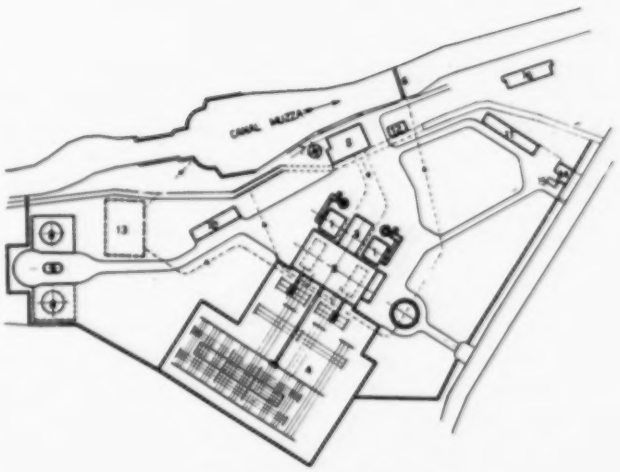
Factors governing selection of the site for the station were: (1) proximity to the gas wells; (2) nearness to Milan, Italy's main power consumer center and at a junction point of the main high-tension transmission network of the component companies; and (3) availability of adequate condensing water from the Muzza irrigation canal which is supplied by the Adda River, backed by Lake Como. The temperature of this water averages less than 60 F for the year and during the winter months when the plant is expected to carry peak load, the temperature will range from 40 to 50 F. This is most important from the standpoint of reduction in fuel rate. Inasmuch as this water is low in dissolved solids and contains practically no suspended matter, it is excellent for boiler makeup after simple treatment.

As this new station is to operate, in a sense, as a demonstration plant and is expected to carry base load up to its full capacity for over 4000 hr per year, advanced design, including high pressure, high temperature and reheat, were justified. A very low fuel rate is anticipated.

The principal features of the station design are as follows:

1. Employment of the so-called unit system with each of the two 62,500-kw maximum capability turbine-generators served with steam at 1850 psig, 970 F by its own 475,000-lb per hr boiler and delivering electric energy to its individual step-up transformer. Each such unit has its auxiliaries, the power for which is taken from the main generator terminals.

2. Steam is expanded in the high-pressure turbine to around 425 psig, then returned to the boiler and reheated to the initial temperature at which it enters the intermediate pressure section of the turbine. The maximum steam temperature at the superheater outlet was held to 970 F in order to avoid use of austenitic material with its accompanying higher cost.



Outline plan of station

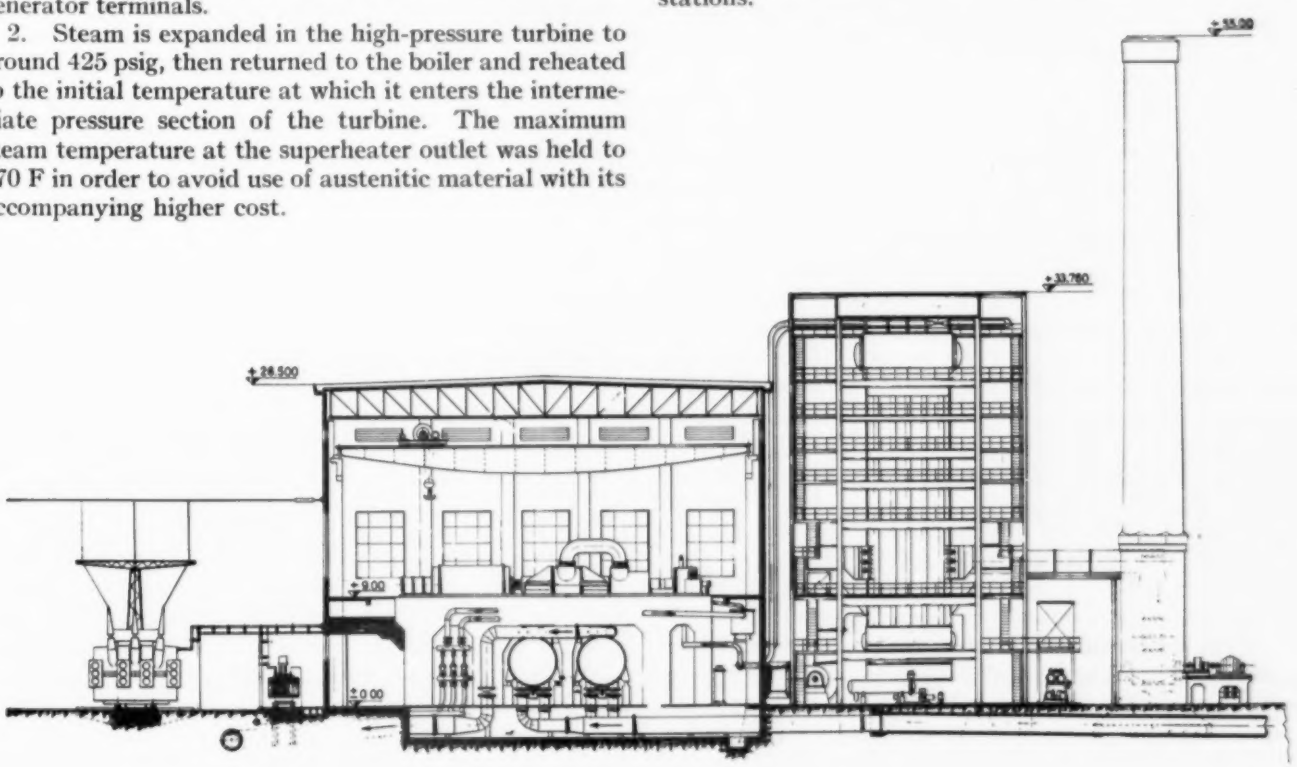
3. The forced-and induced-draft fans, boiler feed pumps, condenser circulating pumps, condensate pumps and other auxiliaries are all driven by electric motors.

4. The steam generating units are installed entirely outdoors.

5. Automatic regulation and control of all thermal and electrical equipment has been provided with a single control room for both types.

6. When natural gas is burned, which is the normal anticipated procedure, it will first be pre-expanded through a gas turbine to utilize the pressure drop before passing to the furnace for burning. The electric energy thus produced will amplify that generated by the main units at practically no expense of thermal energy and so increase the overall station efficiency.

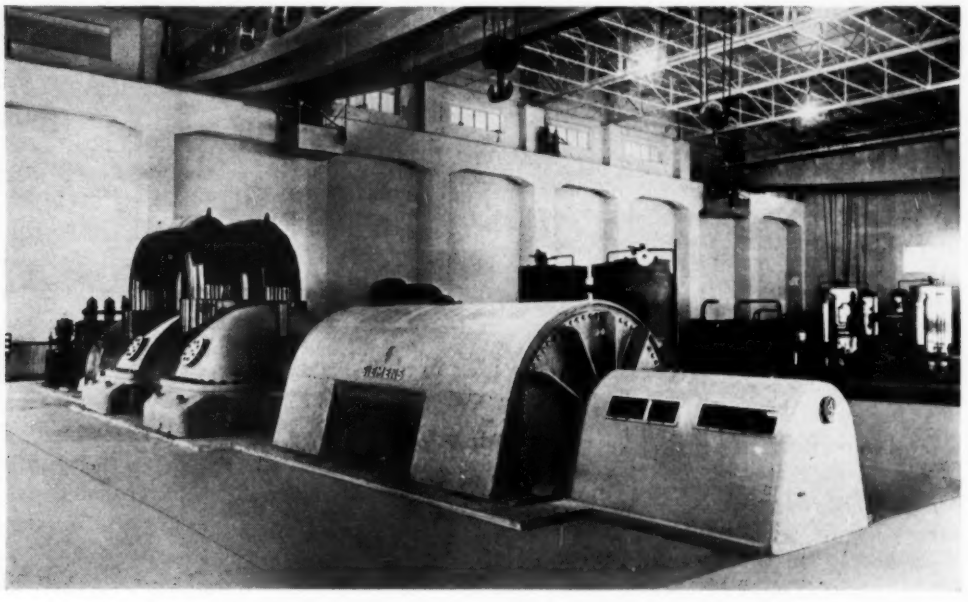
7. Totally enclosed electrical control boards are employed for the 380-and 6000-volt switchgear. There are 130-and 220-kv outdoor transformer and switching stations.



Sectional elevation of station

8. The main generators are hydrogen-cooled.

Reference to the flow diagram indicates that for every 100 Btu in the fuel entering the furnace, 40.5 in the form of electric energy will be available at the generator terminals. From this must be subtracted the auxiliary power requirements of about 5 units, and another 0.5 unit covers transformer losses; so that in the end the electrical energy measured at the high-voltage output should correspond to about 35 per cent of the thermal energy put into the furnace (measured on the lower heat value of the fuel). This, of course, is under the most favorable load conditions. The pre-expansion of the gas turbine should add another one per cent to this figure. If these calculations are confirmed by test, it should be possible to produce a net kilowatt-hour at the outgoing terminals of the station for about 9760 Btu with oil, or slightly less with natural gas. Under normal operating conditions a somewhat higher station heat rate is expected.



Turbine room with one of two 62,500-kw units

Boilers are of the Combustion Engineering-Superheater radiant, reheat type with 66-in. steam drum and plain-tube furnace walls, each having a maximum continuous rating of 475,000 lb per hr of primary steam (420,000 lb reheat steam). Incorporated in each of the two units are an Elesco two-stage, pendant-type superheater, interstage reheater, economizer, tubular air preheater and tile-covered water screen at the bottom. The furnace is tangentially fired with three sets of tilting burners, two of which are for burning natural gas or oil and the third for lighting off.

Steam temperature is controlled automatically by burner tilt, supplemented by desuperheating. The design calls for maintaining the prescribed temperature over a load range from 326,000 to 475,000 lb per hr of primary steam. Design pressure is 2080 psig and the operating pressure at the superheater outlet is 1850 psig.

An automatic blowdown system is provided and incorporates a heat exchanger whereby heat in the blowdown water is recovered and returned to the cycle.

There are twelve automatic sequential soot blowers per boiler, of which eight are of the retractable type and four rotary. Blowing operations are centrally controlled. The blowing medium is steam and the blowers are operated by air.

Each boiler is served by a forced-draft fan driven at 975 rpm by a 410-kw, 6000-volt motor provided with servo-controlled regulation. The fan has ample margin to take care of increased resistance due to possible incrustation of the blades, and provision is made for the recirculation of 25 per cent of the combustion air while burning oil, in order to prevent condensation in the air preheater.

There is also an induced-draft fan for each boiler, driven through a hydraulic coupling by a 660-kw, 6000-volt motor.

Feedwater for each boiler is taken from a deaerator tank by three centrifugal pumps, directly driven at 3000 rpm by 1250-kw, 6000-volt motors. These pumps are designed for an output of 374,000 lb per hr against a head of 2300 psig. However, at the most economical load only one pump will be required; above that two pumps will be operated in parallel; and the third pump is a spare. The pumps are cut in automatically.

Steam Piping

The main superheated-steam line is of special steel (Marwe 17L), manufactured in Germany, with the joints welded according to VDI rules. The inside diameter is approximately $7\frac{1}{2}$ in. (189 mm) and the wall thickness is approximately one in. (26 mm). At the point of junction with the turbine, flanges with welded metal gaskets have been employed. The line from the reheater to the turbine is of similar steel.

Main Turbine-Generators

These are each rated at 62,500 kw capability and are of three-cylinder radial condensing type built by Siemens Schuckertwerke Aktiengesellschaft (Germany), the low-pressure cylinder being double flow. Steam conditions at the throttle are 1778 psig and 950 F for both the initial and the reheat. The generators, with 83 per cent lagging power factor, are rated at 75,000 kva with air cooling and 85,000 kva with hydrogen cooling. The frequency is 50 cycles and the speed 3000 rpm.

There are five bleed points on each turbine at absolute pressures of 320, 120, 50, 20 and 3.2 psia.

Each machine is served by two double-flow condensers having brass tubes and equipped with two condensate pumps. Hydraulic ejectors are employed for air extraction.

Condenser cooling water is taken from the Muzza Canal and enters the pumping station after passing through Beaudrey horizontal and vertical filters which are automatically controlled by a regulator calibrated according to a pre-established value of heat loss in the water passing through them. This water is tapped for cooling bearings, etc., but the major portion is pumped to the condensers by three vertical pumps of 7000 cfm each against a head of 23 ft.

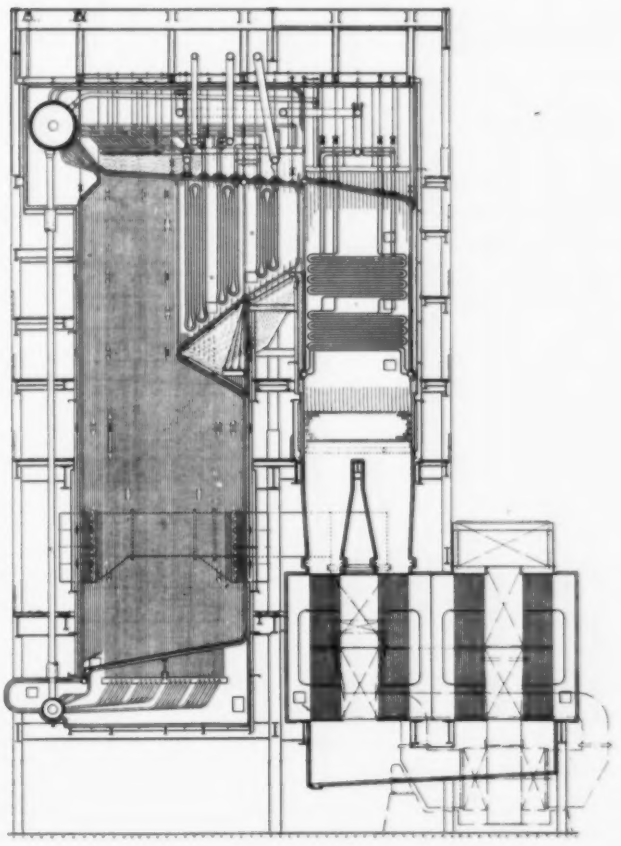
The canal between the pumps and the condensers is mostly of concrete construction and at the condenser outlet special metallic joints connect to the discharge canal.

Distilled water from evaporators is used for boiler makeup, the evaporator feed being pretreated. The water treatment is supplemented by chemicals applied to the boiler water.

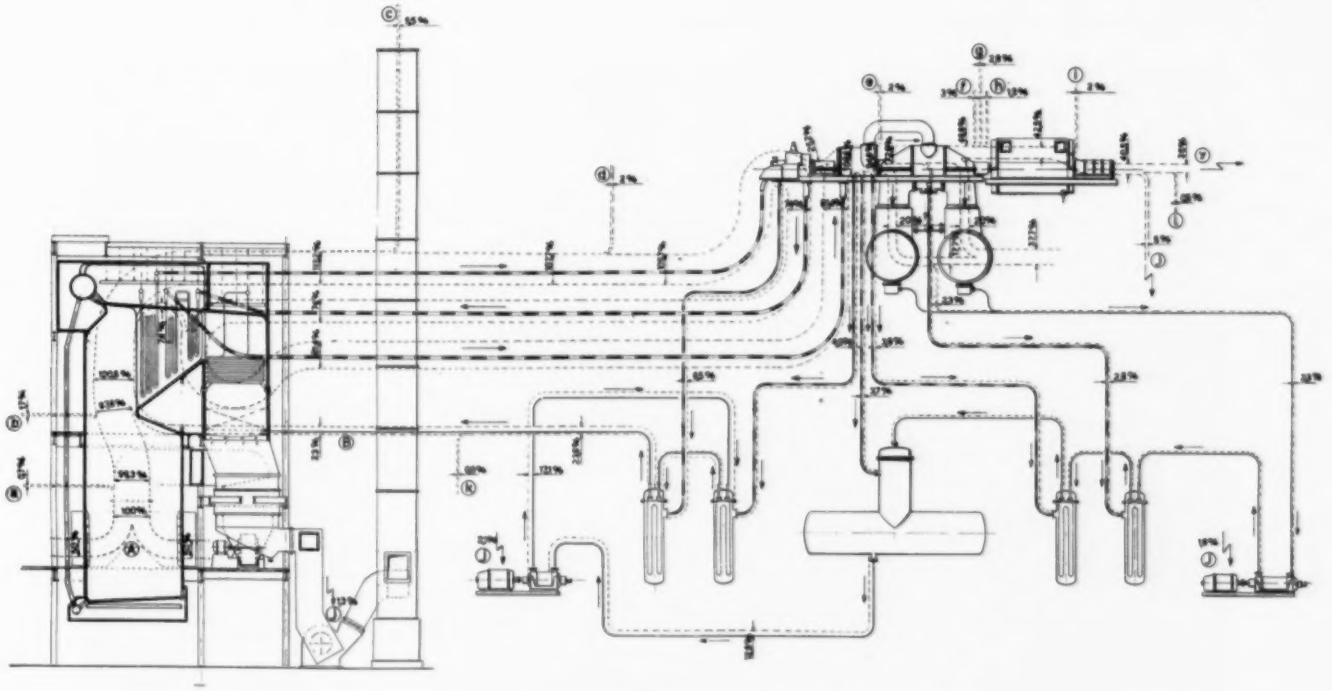
Fuel Supply

As previously noted, the boilers are designed to burn either natural gas or oil, the former being supplied to the plant through a single pipe line terminating in the metering room which contains temperature and pressure recorders for the purpose of making corrections to standard conditions. There is also a recording calorimeter.

The metered gas is then distributed to the two boilers through two underground lines. Here are installed two pressure-reducing stations consisting of an automatically

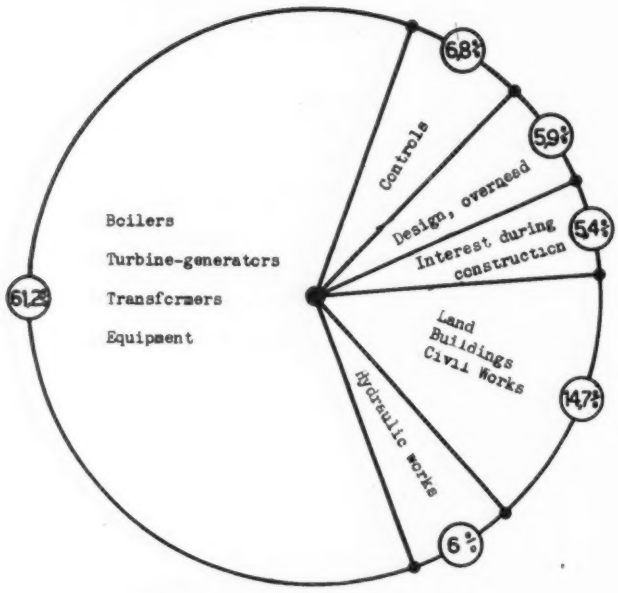


Section through steam generating unit.



Heat flow diagram

A Introduction of fuel heat B Heat added by feedwater a Losses through radiation b Losses through condensation in boiler lines c Losses through latent heat and through unburned gases at the stack d Losses through condensation in the high pressure lines e Mechanical losses and through turbine radiation f Labyrinth losses and others h Losses through condensation in low pressure lines j Energy used up by auxiliary services i Generator losses l Transformation losses y Available energy at the station outlet k Losses through radiation and miscellaneous, water lines, coolers, evaporator



Breakdown of installation costs

controlled steam preheater, servo-controlled reducing valve and in parallel with these are the expansion turbines of special construction. These are controlled for constant back pressure.

The fuel oil supply, with its heaters and supply tanks, is backed by a large storage tank.

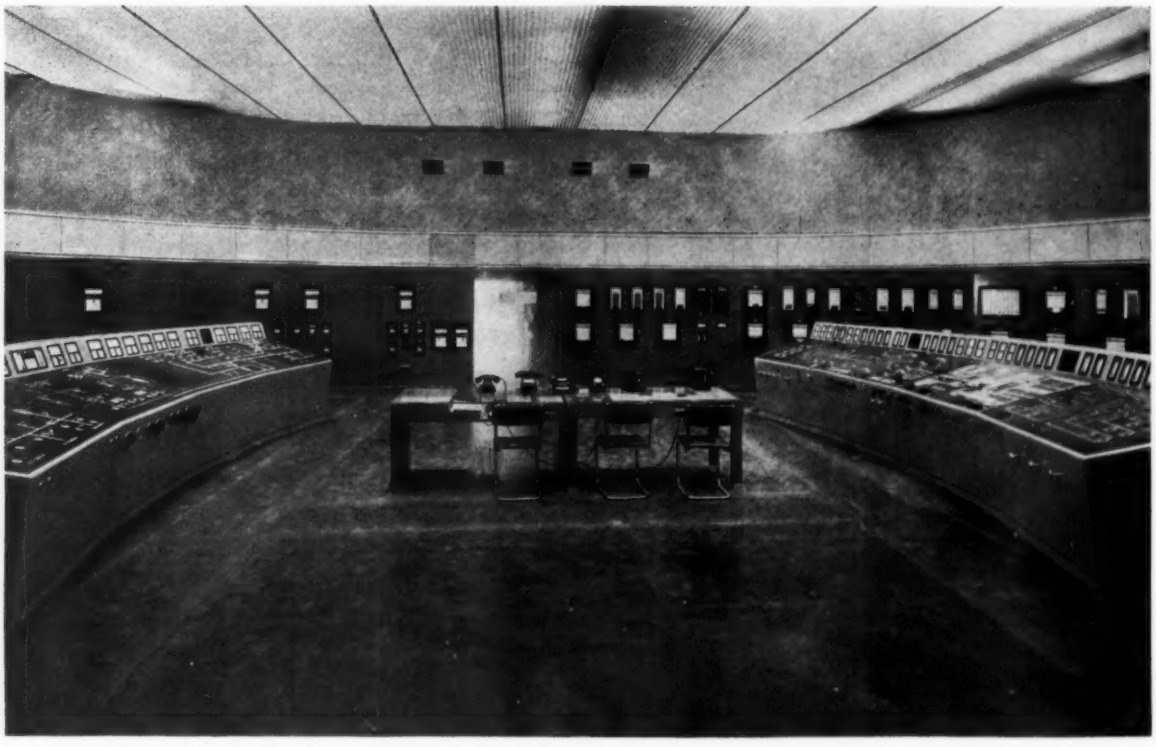
Control Room

All controls, both thermal and electrical, are centralized in a control room so situated as to minimize lengths of control piping and cables. Here are located all boiler controls, together with indicating and recording instruments, controls for starting and stopping the units and for operation of the 130/220-kv outdoor substation. There are a thermal control bench, an electrical control bench and fifty vertical panels arranged around the room, as shown in the accompanying photograph. The benchboards contain single-line illuminated colored diagrams of circuits, and on the vertical panels of the thermal section are the indicating and recording instruments for capacity, pressures and temperatures. Points thus covered include fuel, feedwater, steam, air, water, combustion gases and water column. On the vertical panels of the electrical section are the protective relays, as well as the essential indicating and recording instruments. Above the vertical panels are illuminated annunciators that indicate the operation of the protector devices.

The control room is illuminated by fluorescent lighting, a honeycomb aluminum louver being hung below the fluorescent tubes.

The outdoor substation contains two main 75,000-kva transformers connected on the high-voltage side for 220 kv wye, with directly grounded neutral, and for 130 kv delta. There are also two 6300-kva auxiliary transformers connected to the main units and 12,000-kva auxiliary transformers connected to the 130-kv outside system which are required for starting the units. The oil circuit-breakers for the generators and for the lines are of the reduced-volume type with electro-pneumatic closing. The disconnect switches also have electro-pneumatic control for both opening and closing.

The S.T.E.I. obtained the financing necessary to meet the cost of the project in considerable part by support from the partners, partly from the Banca per il Credito a Medio Termine, and the remainder from the Istituto Mobiliare Italiano with E.R.P. funds. The portion used from this latter loan has covered the purchase of the boilers built in the United States, together with their various accessories, which represents about sixteen per cent of the cost of the entire installation. A breakdown of the installation cost for the different parts of the plant is shown herewith.



View of centralized control room

Cincinnati Host to ASME Semi-Annual Meeting

MORE than a thousand mechanical engineers gathered for the 1952 ASME Semi-Annual Meeting held at the Sheraton-Gibson Hotel in Cincinnati on June 15–19. Supplementing the usual technical program were a number of outstanding general-interest addresses and inspection trips to the recently dedicated Walter C. Beckjord Station of the Cincinnati Gas & Electric Company, the Lockland gas-turbine plant of the General Electric Company, and the headquarters manufacturing center of the Cincinnati Milling Machine Company.

At the opening luncheon ASME president **R. J. S. Pigott** used as his topic, "The Position of the Engineer in These Times." Drawing a distinction between engineers and those engaged as physicists and chemists, Mr. Pigott observed that *experience*, rather than additional academic training, is an absolute essential for the engineer, who must always be aware of the practical applications of science. In regard to college education, there is danger that the young engineering student may not know his technical interests fully and thereby embark upon a premature program of specialization. He urged that more effective methods of teaching mathematics be devised so that it could become a more enjoyable subject and less of an ordeal to students.

"Technology in a Troubled World" was the topic chosen by **William C. Foster,** Deputy Secretary of Defense, for the Roy V. Wright Lecture. Paying tribute to the late Dr. Wright as an outstanding technical editor, Mr. Foster noted that he served as a fine example to instill in the young engineer his own deep and fervent interest in politics. Today no American can afford the luxury of narrow personal goals to the exclusion of civic responsibility, for indifference to this type of participation is the "cancer" which destroys democracy. There is an urgent need for more use in government of the type of skills and discipline possessed by the engineer. In view of the rapid rate at which problems develop in the world of today, more and more leadership must be developed among young people so as to provide a continuing flow of this quality to top management in government and industry. Mr. Foster reassuringly reported that one could work at a very high level in government without the necessity of deviating from one's own personal ideals.

Calvin Rice Lecture

This lecture, prepared by **Dr. Piero Ferrerio,** chairman of the National Association of Italian Power Companies and also of the Edison Company of Milan, reviewed the Italian power situation. He pointed out that, although dependence had heretofore been almost exclusively on hydroelectric power, this had approached full exploitation so that henceforth steam power must be developed to meet that country's rapidly growing power demand.

Since Italy is lacking in coal and oil, an increased power output based on imported coal as fuel would adversely affect the Italian currency balance; but fortunately, large natural gas resources have recently been tapped and show favorable indications of substantial future production. At present all activity in the natural gas fields is practically concentrated in a Government monopoly, which seems to be following a discriminative policy between consumers and a price policy that is not encouraging increased consumption.

Dr. Ferrerio observed that a few large power stations are now being built or planned to burn domestic natural gas and expressed the opinion, from the viewpoint of the Italian power industry, that prospecting for and utilization of oil and gas reserves in Italy should be open to all organizations capable of undertaking such activity, on the basis of clear and practical legislation that must combine the interest of the general public and that of these organizations. In fact, this is what was done in Italy for the exploitation of hydroelectric resources which was undertaken jointly by different types of enterprises within the framework of wise legislation covering public waters and electric installations.

"The national power output for 1951," said Dr. Ferrerio, "was 29.3 billion kilowatt-hours, of which 26.5 billion were hydroelectric and the remainder geo-thermic (where natural steam issuing from the earth is the source of power) and thermoelectric. This aggregate output will be exceeded this year."

Rehabilitation of the Italian power industry after the damage and destruction of installations during the last war, and the construction of new installations to allow for expansion of the industry, has been accomplished at the expenditure of $250,000,000 a year, Dr. Ferrerio pointed out, and added further: "The effort involved in the expansion of the electric industry in Italy has been proportionally greater than that of other much richer European countries. In fact, the yearly average percentage increases in capacity between December 31 1946, and the end of 1951, were 8.51 per cent in Italy, 6.4 per cent in France and 6.95 per cent in England. But the financial effort for Italy is still larger when one considers total expenditure rather than capacity. This is due to the fact that England is practically 100 per cent a steam power country and France approximately 50 per cent hydroelectric. The investment required in Europe today for the installation of hydroelectric capacity is two to two and a half times that for a corresponding steam power capacity. Therefore, the financial expenditure of the Italian power industry can well be considered much greater than that of other countries with far larger financial resources."

Symposium on Training Power Plant Personnel

A series of five papers, four from the public utility industry and the fifth from a large industrial organization, constituted the symposium on the selection and training of personnel for steam-electric generating stations.

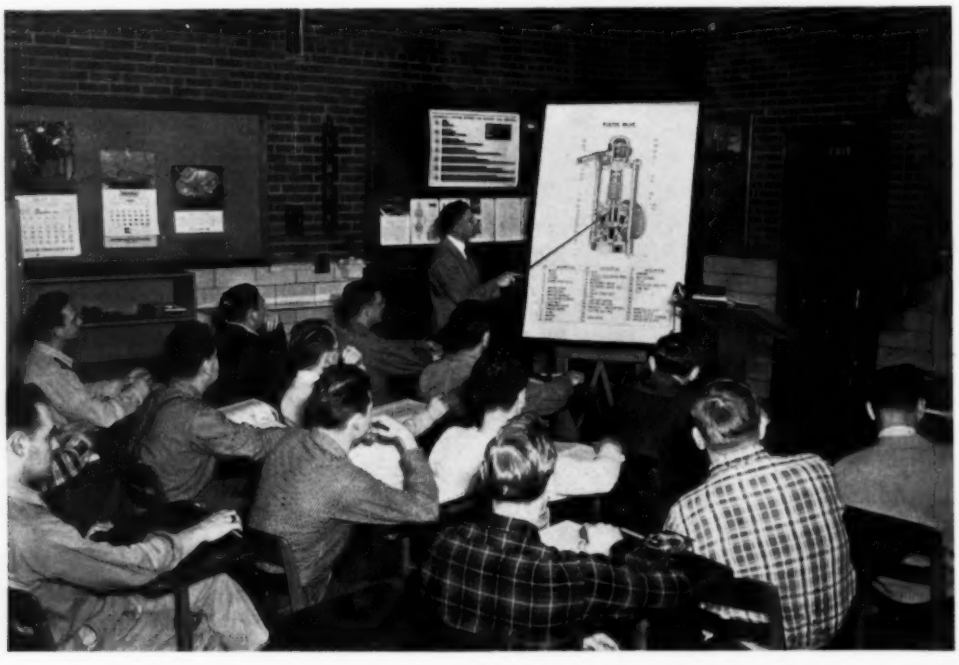
F. E. Nicoson of the Noblesville Generating Station of the Public Service Company of Indiana, Inc., emphasized that stations now being constructed require that the operator have a knowledge of turbine, boiler and electrical phases of operation instead of being specialized in just one or two of these. To meet this requirement a well-rounded training program is a necessity. In general, those selected should have maximum potential ability for learning, and they should possess individual initiative, aptness and ambition in sufficient degree to aid in the absorption of phases of operation in which they are least experienced. It is important that key employees be on the site well ahead of startup so that they may become familiar with the overall installation.

In the second paper **J. D. Williamson** of The Dayton Power & Light Company described how his company assembled and trained the necessary personnel for a second generating station from a limited number of employees. To accelerate all phases of the training program, classes in steam-plant operation were started so as to acquaint the men selected with the basic principles of plant equipment and its operation and to assist them in passing the requirements of the Ohio license for stationary steam engineers. The final preparation took place at the plant and consisted of four weeks of schooling attended by all operating personnel and a few key maintenance employees. In addition to the station staff, manufacturers were requested to provide qualified representatives to give detailed instructions on the construction, operation and maintenance of the major equipment items.

The third paper by **Albert H. Beiler** and **John E. Geue** of the American Gas & Electric Service Corporation contrasted old and new methods of instruction, particularly in terms of the greater demands placed upon operators during the last decade because of the increased generating-unit investment per operator. To carry on a successful educational program requires the full and continued support of management and an insistence that engineering specialists write operating instructions in advance of starting up. Effective illustrations are a considerable aid to instruction, and much thought should be given to their preparation. Plant libraries have also been started in most of the companies of the system so that all operating employees, not just those in a supervisory capacity, may have access to books, magazine files, slides and other information which will help them in their work. Texts are provided to cover pertinent mechanical, electrical and shop subjects. The authors strongly emphasized that preparation of operating instructions is a full-time job that requires competent pedagogical, engineering, artistic and drafting personnel.

An extremely comprehensive and intelligently organized program for training operating personnel of the Dow Chemical Company was described by **D. F. Steinke** of its power educational department. This program is not begun in the conventional formal textbook manner; instead trainees are enabled to get the "feel" of things through short review courses in the form of movies dealing with various phases of power generation. All classes meet once each week on company time for two hours with the stipulation that two hours of home study be assigned each student. A passing grade of 70 per cent is required, and all successful students receive as personal property the textbooks and instructional material loaned during the course. An additional incentive is provided through visitations to outstanding power facilities in the vicinity of the plant. Almost every type of visual aid is employed, along with huge models of small tools and cutaway models of various power plant equipment. There have been about 1100 graduates from all of the various courses since their start about six years ago.

The last paper in the symposium was by **Vern L. Stone** of the Commonwealth Edison Company of Chicago who discussed the stages in training men for the Ridgeland Station, the first centralized-control installation on that system. Control-room supervisors were relieved of their former duties six months in advance of



Class of firemen and engineers at Dow Chemical Company receiving instruction in design and operation of feed water equipment for 1250-psig and 400-psig systems

the startup of the new plant and given diversified experience in existing stations. An especially important factor in the selection of all personnel for centralized-control operation was the possession of a cooperative attitude that results in effective team work. The author attributed much of the success of the new station to this spirit of cooperation and the conscientious helpfulness of all operating personnel. No attempt was made to assign men to specific jobs within the control room, and very little trouble that could be attributed to operating errors was encountered during initial operation of the plant.

Discussion

W. V. Drake reported that West Penn Power Company had found that young engineers gain valuable experience for themselves and for their company if they are assigned to the task of training central-station operators. One engineer reported that a good source of operating personnel was found among those who had had service in the Navy. Another suggestion pertaining to junior engineers was that they work in conjunction with specialists in the preparation of operating instructions and be made responsible for a rigorous job of proofreading of this material. **A. C. Pasini** of the Detroit Edison Company listed these qualifications for operators: (1) temperamentally fitted to the job, (2) ability to lead and get along with men, and (3) the requisite know-how and the ability to learn quickly.

Design for Ohio River Flood Conditions

D. C. Hormell of Pioneer Service & Engineering Company presented a paper entitled "Design for Extreme Flood Conditions at the Paddy's Run Station" in which he explained a number of rather unconventional solutions to special problems encountered by the Louisville Gas & Electric Co. in its Ohio River steam generating stations.

An interesting but very complex problem in structural design, hydraulics and economics was presented by the condenser circulating water system and related pumps at the time construction was started in 1941 at the Paddy's Run Station. Because of the nature of the site, the orthodox approach (that pumping head should at all times be within the limits of a practical syphon) was ruled out, or at least definitely restricted. The advantage of having the pumping equipment located within the plant was investigated, but this entailed caisson or deep-pit construction, since the variation between *design* high water and low water involves a range of 88 ft. In addition, serious obstacles to cleaning traveling water screens under flood conditions were encountered. It was finally decided that a separate river screen house appeared most advantageous, and this was designed suitable for continuous operation at all stages from lowest river elevation to extreme flood conditions.

With more conventional design, condenser water boxes may be planned for comparatively low pumping heads, 30 psig or less, permitting use of cast-iron construction. Because of the 83-ft range between extreme river stages the Paddy's Run shells are of structural steel and the water boxes are of fabricated-steel construction, designed and structurally braced to withstand an internal pressure of 70 psig.

With little or no precedent in the power industry to guide in the selection of equipment for a differential head of 83 ft, the question might be raised as to the cost of the special equipment. Although that which was installed represented a greater capital investment than more conventional equipment, detailed studies indicated that the arrangement installed resulted in savings in fixed charges which were greater than the increase in operating expense. Over a ten-year operating period reliable performance and comparatively trouble-free operation have justified initial acceptance of the basic design.

Steam Plant Design

In a paper entitled "New Features of Steam Plants on Inland Rivers," **G. V. Williamson** of the Union Electric Company of Missouri enumerated the following three developments which have not been so widely discussed in the technical press:

1. Operation of boiler-turbine unit and all its essential auxiliaries from a compact central-control room.
2. Large capacity in a single boiler-turbine unit, 100,000 kw and higher being common unit sizes.
3. Radical simplification of the power plant cycle, including elimination of many items of piping, variable-speed drives and duplicate auxiliaries which were once thought essential.

The central control room at the Meramec station of the author's company was carefully developed with compactness as an essential but with a full complement of controls and recording instruments within the vision of the operators.

The incentive for large-size units is derived principally from the lower cost per kilowatt of installed capacity, the economic possibility of genuinely adequate controls, and greater productivity from operating personnel. It has been found that a relationship first proposed by M. K. Drewry of Wisconsin Electric Power Company holds for large units, namely: cost per kilowatt varies as the cube root of the number of units.

An example of plant simplification at Meramec was the elimination of all variable-speed drives on boiler-feed pumps, draft fans and circulating-water pumps. This was simply a matter of balancing first cost, maintenance and attention against losses due to increased auxiliary power use and increased wear of the auxiliary due to continuous operation at full speed. Surprisingly, no economic study at Meramec supported a variable speed coupling or motor. Other phases of the same station reflect a modern approach in economic design, such as use of "Galbestos" for building walls, elimination of tile floors in turbine room, elimination of skylights, and minimizing height of turbine-room crane.

Milesburg Power Station

Special features of a 45-mw station of the West Penn Power Company located at Milesburg in Center County, Penna., connected by a 105-mile transmission line to the company's principal network, were described by **W. V. Drake** and **R. A. Mycoff.** The plant is of the semi-outdoor type and consists of two 22,500-kw Preferred Standards turbines, each served by a 210,000-lb per hr. pulverized-coal-fired boiler operating at 900 psig, 900 F. Financing and building a station with comparatively low electrical output was, in the words of the authors, "not only a problem but a necessity." Accomplishment

of that goal is indicated by a cost of $160 per new kilowatt, including land and step-up transformers with circuit-breakers. To do this, excavations were minimized, the deaerator was eliminated by the use of deaerating condenser, the distilled water tank was mounted at ground level, and spare auxiliary equipment was kept to a minimum.

Each boiler was equipped with one forced-draft fan. An opportunity was provided, shortly after the units were started up, to operate the boiler without the forced-draft fan. During a ten-day period one boiler was able to function successfully at loads up to approximately 75 per cent of full rating and to maintain normal 900-F temperature. To analyze conditions of operation with and without forced-draft fans, three and one-half hour comparative tests were run simultaneously with each boiler. There was a difference of 5.3 per cent (82.4% vs. 87.7%) in favor of the unit operating with both forced- and induced-draft fans, this largely being due to higher carbon losses resulting from less efficient combustion and higher exit dry-flue-gas losses. The latter came from the large percentage of combustion air bypassing the air heater because of the necessity of opening the air-heater doors, and also from the leakage of air through the boiler setting resulting from the high negative pressure encountered without forced-draft-fan operation. It was the authors' opinion that the elimination of a second forced-draft fan on each boiler was a sound decision because it decreases initial investment with a minimum effect on overall boiler efficiency and reliability.

Material Handling Facilities

The Walter C. Beckjord Station of The Cincinnati Gas & Electric Company is unique in that it is not situated on a railroad, therefore necessitating that fuel and much of the heavy equipment used in construction be handled by barges on the Ohio River. **Raymond F. Schierland** of the general engineering department of that utility described the river crane and barge equipment that was especially designed and adapted to the particular conditions of the 100,000-kw initial section of this new station.

A receiving area was established at the Company's Miami Fort Station which is located 38 river miles from the Walter C. Beckjord station. Ample land was available there for the rail-river shipping system, and there was an existing spur with the Baltimore & Ohio Railroad. Two cranes having a maximum capacity of 207 tons each were designed for the locations. At Miami Fort the railroad track is brought under the land end of the crane bridge on a steel-beam concrete-pier trestle, where the river bank drops away from the flood plain. To facilitate movement of heavier loads this track has a slight downward-grade toward the crane. At Walter C. Beckjord station a railroad track runs under the land-end cantilever section of the crane, which is perpendicular to the longitudinal axis of the crane bridge. This track has two branches, one leading to the main power transformer area and the other into the station turbine-room unloading bay. Nominal rating of the conventional turbine-room crane is 150 tons, but it is suitable for carrying the same maximum loads (207 tons) as the river cranes.

A floating dock is used for handling coal barges at both stations. The downriver-end barge at each station was designed as a cargo barge provided with special deck construction to take the concentrated load of a generator stator. These barges are bulkheaded into six watertight compartments, and special deck fittings are provided to take equipment lashings. These fittings are removable so that when the barges are functioning normally as a part of the coal docks, there will be no interference with coal-barge shifting cables.

The specially designed material-handling equipment has given complete satisfaction in the installation of the first unit at the Walter C. Beckjord Station. A total of 130 railroad carloads of equipment weighing approximately 2820 tons was shipped by barge from Miami Fort Station. No changes are contemplated in the procedure for future units. Although extra cost is involved, the amount is not excessive and is well warranted by advantages accruing from the station location.

Report of Nominating Committee

The nomination of **Frederick S. Blackall, Jr.,** president and treasurer of the Taft-Pierce Manufacturing Company, of Woonsocket, R. I., as 1953 president of The Society was announced by the nominating committee. The other officers nominated were as follows:

Regional vice presidents:

Henry R. Kessler, (renomination) manager, Republic Flow Meters Company, New York, N. Y.

Paul R. Yopp, district sales manager, the Babcock & Wilcox Company, Atlanta, Ga.

Ben George Elliott, professor of mechanical engineering, University of Wisconsin, Madison, Wis.

Harry R. Pearson, personnel director, Dallas Power and Light Company, Dallas, Tex.

Directors-at-large:

David W. R. Morgan, vice president, Westinghouse Electric Corporation, Philadelphia, Pa.

Ralph L. Goetzenberger, vice president, Minneapolis-Honeywell Regulator Company, Washington, D. C.

Mr. Blackall entered the employ of the Taft-Pierce Manufacturing Company, makers of machinery and tools, in 1922. He became vice president and general manager in 1929 and has been president and treasurer since 1933. He was born at Roselle, N. J., Nov. 26, 1896 and was graduated from Yale University in 1918 with a B.A. degree. He attended the U. S. Naval Academy Third Reserve Officers School the same year and in 1917–1918 served in the Navy with the rank of Ensign. In 1922 he received a B.S. degree from Massachusetts Institute of Technology.

During World War II Mr. Blackall was a member of the U. S. Navy War Manpower Survey Committee, First Naval District; Victory Fund Committee of Rhode Island; Precision Tools and Machine Tool Industry Advisory Committees, and also a member of the War Production Board.

Mr. Blackall is a Fellow of the ASME and a member of the American Society for Metals, American Society of Tool Engineers, Providence Engineering Society, American Ordnance Association, Newcomen Society, Sigma Alpha Epsilon and Theta Tau.

Relation of Spreader Stokers to Air Pollution

In this paper which was presented at the recent Annual Meeting of the Air Pollution and Smoke Prevention Association in Cleveland, the author discusses why some spreader stoker jobs fail to meet the requirements of local smoke ordinances and then proceeds to point out the factors that make for satisfactory performance. A number of typical installations involving several makes of stokers, are illustrated.

By MAX O. FUNK

Combustion Engineering—Superheater, Inc.

TO confirm that spreader stokers, as a type of mechanical coal firing equipment, are a source of much unlawful industrial and commercial smoke, the following figures, as summarized by one municipal Bureau of Air Pollution Prevention, are cited. They show the magnitude of the problem as well. In the community for which these figures were tabulated, spreader stokers comprise $6^1/_3$ per cent of approximately 600 mechanically fired units in industrial installations, and they produced 36 per cent of the industrial violations for the year 1951.

Most of the spreader stoker manufacturers are aware of this situation and have directed their efforts at attempting to correct it. Appreciating the advantages and appeal of spreader firing, the manufacturers cannot afford to let a situation of this kind continue. Collectively, they have participated with Bituminous Coal Research in a program to study the reduction of dust emission from spreader stokers. The results of this work were presented by Engdahl and Holton at the A.S.M.E. Semi-Annual Meeting at Toronto in June 1951. Individually, they have directed their engineering and research talent toward the development of spreader stokers which will operate without violations of municipal air pollution codes. Hoping to present this paper for the spreader stoker manufacturers as a group, the author has included comments and illustrations from three companies beside his own. These will show the present status of modern designs of stokers, and the more recent developments can be applied to older stokers in a limited way.

It would be interesting to break down the above-mentioned violation record to show the ages of the stokers which commit most violations, as such a study would likely show that the older stokers are the principal violators. When spreaders first became popular, they were installed in many instances where they were not adaptable. They were also installed in large numbers when the art of spreader firing was in its early stages of development and everyone was learning. In later years engineering standards have changed drastically, and spreader performance has improved.

Historically, no one design feature is responsible for generally improved performance, and experience in operation of such spreaders has shown that no single correction or addition to a unit can change it from a violator to a non-violator. For their effect on smoke and dust emission, many factors in design and operation contribute to making good jobs. All features of design and operation must contribute to the maintenance of certain basic conditions in a spreader-stoker-fired furnace. These are equal burning on each unit of grate area, adequate mixing of the combustible material and air at temperatures which will carry the combination to completion quickly; also, sufficient time or flame travel for combination to be completed before the gases pass over heat-absorbing surfaces.

The stoker itself should be designed to assure, to as great a degree as possible, a positive and continuous flow of coal to the furnace. Each manufacturer has his own method of accomplishing this. One method of feeding coal, as applied by the American Engineering Company, is shown in Fig. 1. This feeder incorporates a scraper chain which moves continually to discharge the coal onto the distributor. The speed of the scraper chain is varied according to load demand. The throat marked *X* serves to prevent avalanching of coal from the hopper. Other manufacturers use various types of rotary or reciprocating feeders, but the important thing is that each has a positive metering device which prevents an uncontrolled flow of coal into the furnace.

Another important factor which affects continuity of coal flow is water in the coal, and most stoker feeders can handle reasonable moisture content. If the coal becomes

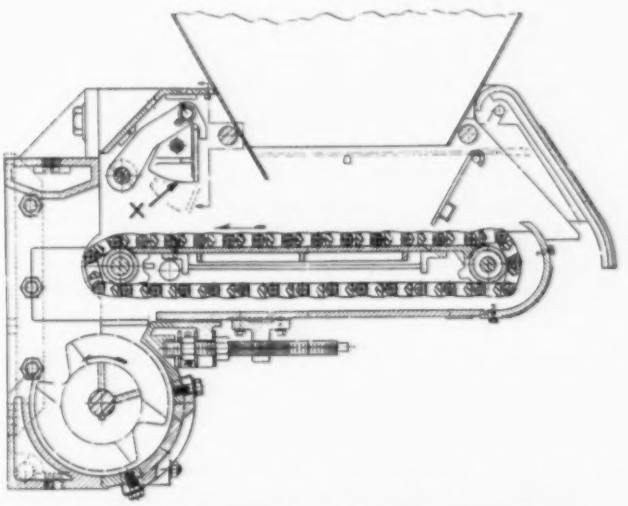


Fig. 1—One method of feeding the coal

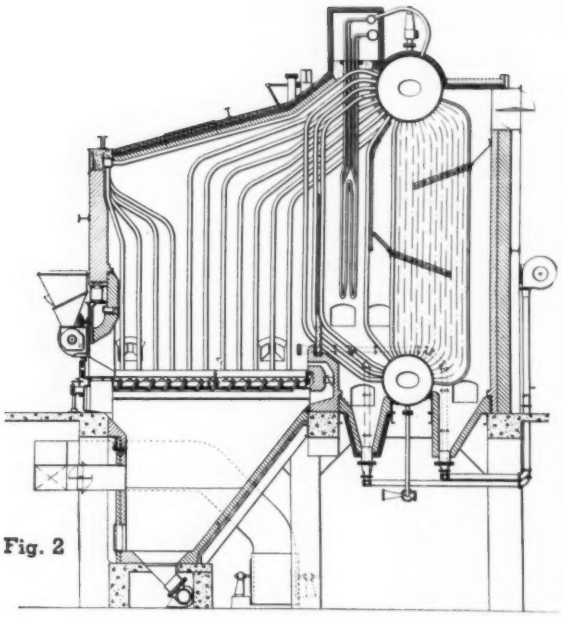


Fig. 2

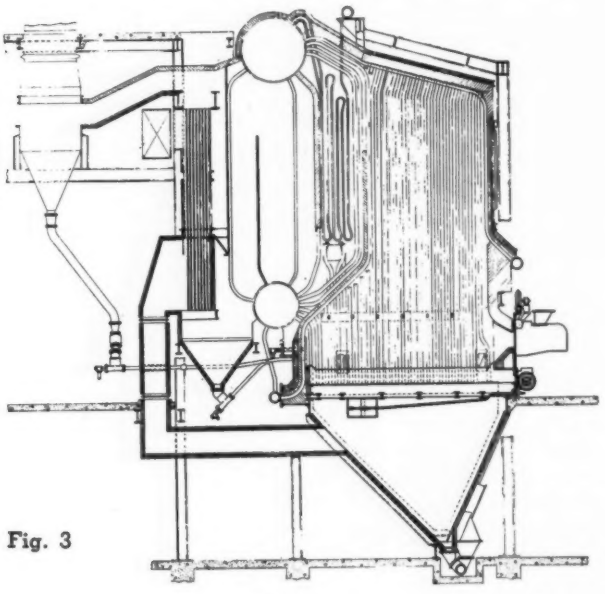


Fig. 3

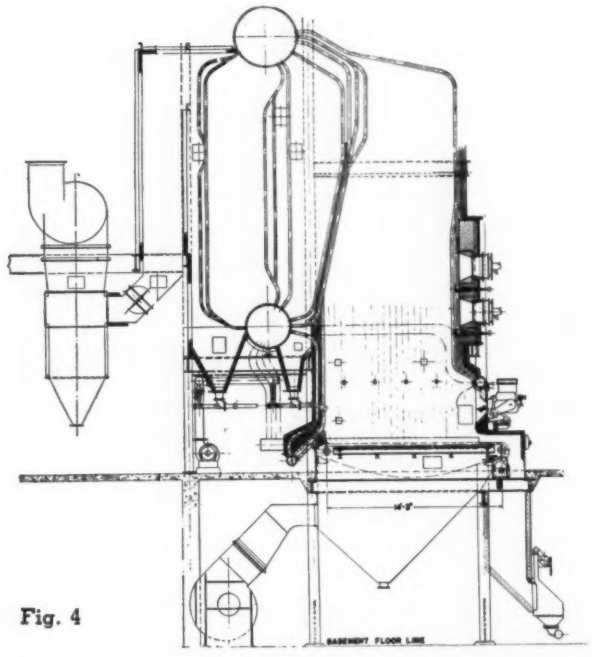


Fig. 4

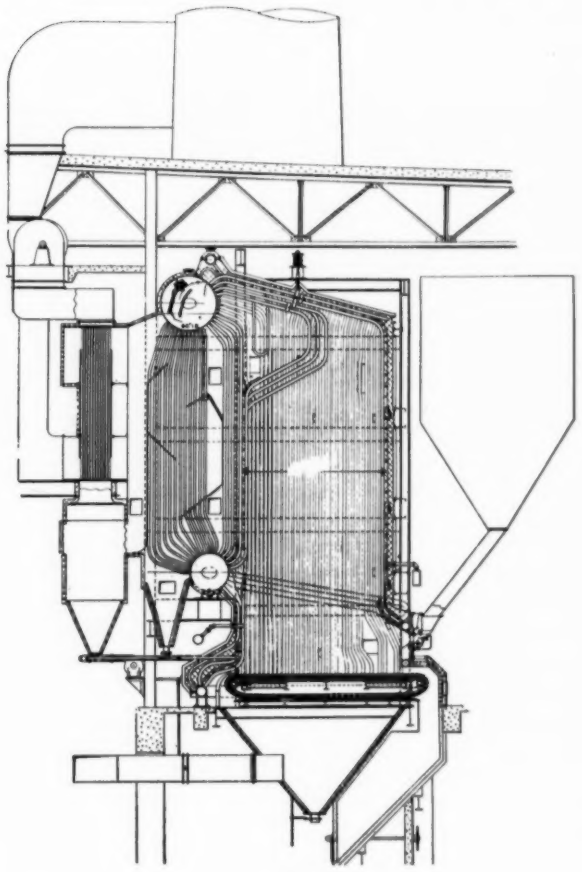


Fig. 5

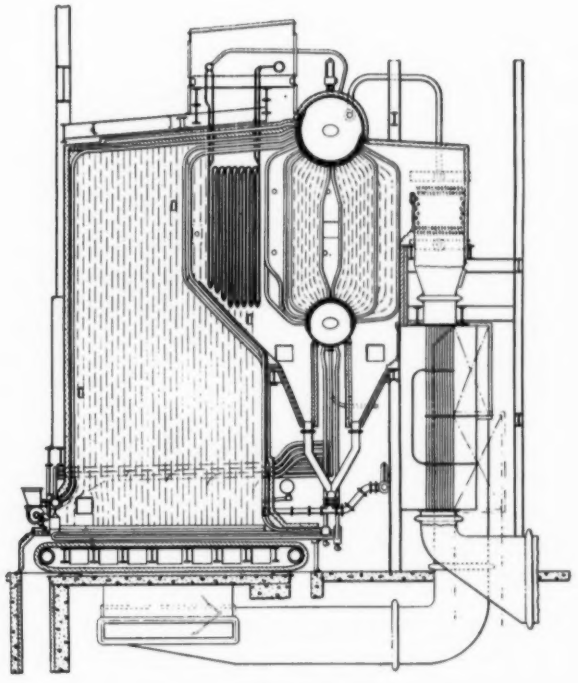


Fig. 6

Figs 2 to 6—Typical spreader stoker installations

so wet that feed to the furnace is interrupted at any point in the handling system, positive control of feed is lost, and smoke and cinder carryover will undoubtedly result. Positive control of coal feed cannot be stressed too strongly because successful spreader operation is impossible without it.

After the coal leaves the feeder, it passes through a distributor which must be capable of delivering equal coal concentrations on each unit of grate area. If coal on the grate and air under the grate are not kept in balance, smoke will result. Some limited corrections for improper coal distribution can be made by undergrate zoning of the air chamber and separate zone control, but this approach cannot be expected to correct for widely varying coal distribution over the grate area.

If coal and air distribution are uniform over and under the grate and the supply of each is maintained in proper proportion to the other, one basic requirement for good operation is met. If it were possible to have an infinite number of air openings through the grate, a second basic requirement could also be met at the grate line. However, even though air can be directed through the grate in such a manner as to produce mixing with the combustibles, some means of inducing mixing above the grate line is generally necessary. This mixing by means of steam or air jets and, to a lesser extent, through the use of arches, has been widely explored and has been reported in many papers and articles. It is generally admitted that overfire turbulence is necessary for control of smoke and dust emission, and today all major spreader stoker manufacturers provide some method of inducing such turbulence.

However, while overfire turbulence alone is not the answer to all smoke and dust emission problems, it can contribute greatly toward attaining that objective and, in combination with other factors, can assure control of the emission to acceptable limits.

Furnace temperatures at and immediately above the grate line are also extremely important for smokeless spreader-stoker operation. When these temperatures fall too low, smoke will result. For a given furnace, temperatures are a function of burning rate, or grate heat release and excess air. If burning rates become too low or excess air becomes too high at low load operation, smoke will be formed with most high-volatile coals. Operation with most low volatile coals is not as critical, and lower burning rates can generally be maintained without smoke violations. In selecting equipment an attempt should made to keep burning rates on the grate above 125,000 Btu per sq ft per hr at the lowest point of continuous operation. Although fires can safely be maintained below this point, this is one of the advantages of spreader stokers that has hurt their reputation as much as anything. The best solution is realistic load estimates and the use of multiple units where necessary to maintain adequate low-load burning rates.

Excess air in spreader-stoker furnaces must be maintained constant for a given set of conditions and should be varied inversely, within limits, with burning rates on a given stoker. This requirement in combination with the spreader stoker's ability to change burning rates rapidly makes automatic combustion control essential for acceptable operation. Although the author has operated spreader stokers on complete manual control with variable steam demand and maintained a smoke discharge within the limits of local smoke regulations, this would not be possible in routine operation nor could it be continued for long periods. Automatic controls can do the same job continuously with comparatively little attention from operating personnel. Combustion controls should be chosen, however, so that they are not beyond the understanding of the men who must use and maintain them. A control system not in proper adjustment can be as bad as no system at all.

The last of the basic requirements for good operation is adequate time, or flame travel, for the combination of combustibles and air before the gases pass over heat-absorbing surfaces. The necessary time for completion of the combustible combination can be gained through low vertical gas velocities and high furnaces. One basis for comparison of furnaces is the heat release per cubic foot of furnace volume. For nine recent and modern jobs this figure has varied between 21,200 and 30,000 Btu per cu ft per hr. Even with these low release rates, the physical arrangement of the furnace must be such as to allow adequate linear flame travel and low vertical gas velocity.

Even after all basic requirements for good stoker operation have been met, some cinders will be carried out of the furnace and into the boiler passes and beyond. Consequently, cinder return to the furnace must be considered. Most manufacturers agree that on modern jobs with dust collectors, cinders can be returned to the furnace from boiler, economizer, and air heater hoppers without exceeding dust loading limits of most dust codes. However, there exists some difference of opinion as to justification for return to the furnace of refuse from dust collectors. Much research into this part of the problem has been done by the manufacturers, collectively and individually. No agreement can be reached on the actual quantitive effect on dust loading at the stack when dust collector refuse is returned to the furnace. There is agreement, nevertheless, on the conclusion that return of this refuse does increase stack dust loading. Attempts have been made to determine, by test, the amount of the increase, but the results have been inconsistent.

Although spreaders can burn a wide variety of coals successfully, they cannot burn "anything black" and maintain satisfactory stacks. Sizing of coal is more critical than quality, but both must be considered. This is the most intangible part of the problem, and it is the part which generally receives the least attention. It is evident that excessive fines contribute to excessive carryover from the furnace and that excessive moisture interrupts consistent flow of coal to and thereby contributes to smoke. Over and above these, there are also certain physical and chemical properties which affect smoke and carryover. This phase of the problem requires more attention than it has received in the past. It may explain some of the inconsistencies in the results of test work with spreader stokers. More generally, a spreader should not be limited to a single source of coal. Users would prefer to handle any coal that is supplied to their stokers, but when results with a given coal are consistently poor, a change in supply is in order.

With proper control, operation of a spreader stoker can be relatively simple, and it has been the author's experience that most good jobs require very little attention from operating personnel. Major changes in steam demand or coal consistency require an operator's attention,

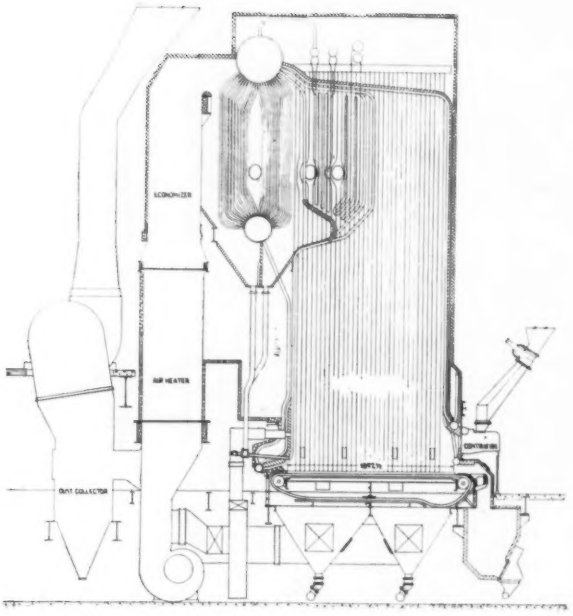


Fig. 7

but after he has stabilized conditions in the furnace, he can usually let the unit and its controls alone.

Mechanical maintenance of stokers and control equipment is extremely important, primarily because of its effect on the flow of coal into the furnace. A well-maintained unit is generally one which will be a non-violator, but without maintenance the same unit will probably become a violator. This does not imply that spreaders and their controls require constant attention, but a well-planned preventative maintenance program will contribute much to their successful operation.

There are here illustrated several examples of modern spreader-stoker installations which meet the basic requirements for successful performance. These examples are from four manufacturers, but the lack of examples from others does not imply that they do not meet the present conception of good, basic design. To avoid any semblance of partiality, these units will be shown in the order of their size, beginning with the smallest.

Fig. 2 shows a Combustion Engineering—Superheater unit designed for 30,000 lb of steam per hour. This represents an actual job involving a two-drum boiler with a superheater and a dump-grate spreader. Although not shown in the sketch, a high draft loss collector was included. Cinders are returned from the boiler passes but not from the dust collector. Overfire steam jets are employed for turbulence. The furnace heat release at 30,000 lb per hr is 23,000 Btu per cu ft per hr, and minimum flame travel is 12 ft.

Fig. 3 shows a Westinghouse link-grate "Centrafire" stoker installed for a maximum load of 60,000 lb of steam per hour. An arch-type furnace is employed and is quite effective in minimizing smoke. Furnace heat release is 27,000 Btu per cu ft per hr at maximum load, and minimum flame travel is 17 ft. Cinders are returned from the boiler passes but not from the dust collector. Overfire air equipment is installed, but not used with the arch-type furnace.

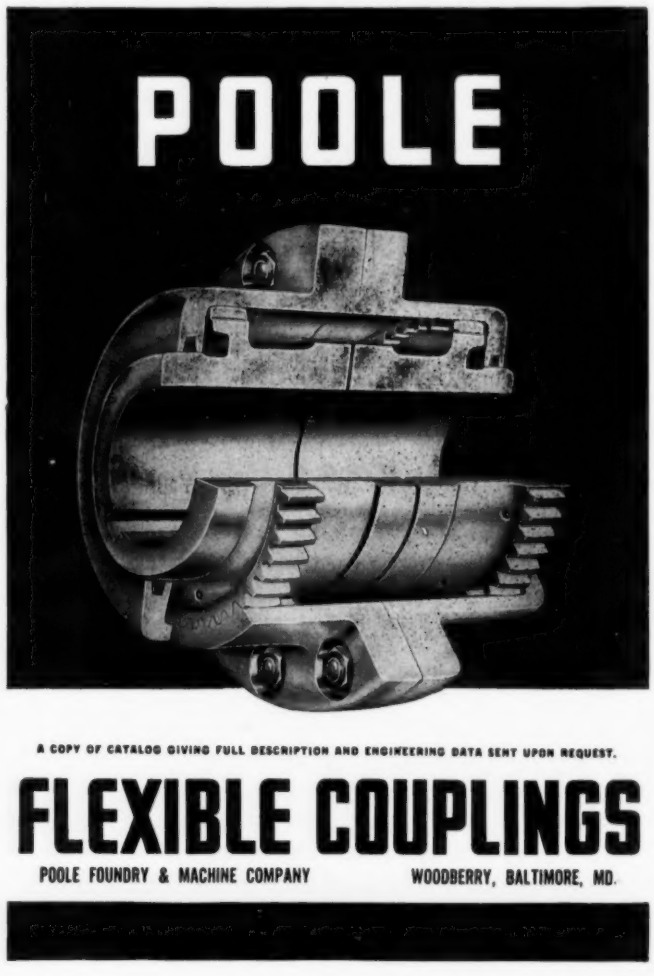
Fig. 4 shows an American Engineering stoker serving a Springfield boiler, designed for 80,000 lb per hr continuously. Overfire air and cinder recovery from the boiler passes is included, but dust collector refuse is not returned. The furnace heat release is 27,000 Btu per cu ft per hr, and minimum flame travel is 24 ft.

Fig. 5 shows a Riley boiler and stoker unit for 125,000 lb of steam per hour. Overfire air and cinder recovery from both boiler passes and dust collector are included. Furnace heat release is 21,200 Btu per cu ft per hr, and the minimum flame travel is 24 ft.

Fig. 6 shows a Combustion Engineering—Superheater boiler and stoker unit for a steam output of 150,000 lb per hr. Overfire air and cinder recovery from the boiler passes are included. Furnace heat release is 22,300 Btu per cu ft per hr; minimum flame travel is 23 ft, and vertical gas velocity at a place half way up the furnace is 14 ft per sec.

Fig. 7 shows a 200,000 lb per hr Westinghouse stoker-fired unit. Air and cinder recovery from the boiler passes and a trap ahead of the dust collector are included. Dust from the collector is not returned to the furnace. Furnace heat release is 25,000 Btu per cu ft per hr, and minimum flame travel is 25 ft.

All of these examples incorporate modern engineering trends in furnace design for spreader stokers. With furnaces such as these and stokers that meet the fundamentals for good spreader performance, non-violating spreader jobs can greatly improve the record of violations cited at the beginning of this paper, and they can be operated within the smoke and dust limits of municipal air pollution codes.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Beckjord Station Dedicated

The first section of the new Walter C. Beckjord Station of the Cincinnati Gas and Electric Company was dedicated on June 12. Named for the president of that company, the station is located at New Richmond on the Ohio River about 18 miles above Cincinnati and has an initial capability of 100,000 kw. Steam conditions at the throttle are 1450 psig, 1000 F initial and 1000 F reheat. Laid out on the unit system, the 100,000-kw turbine-generator is served by a C-E steam generating unit of the radiant, reheat type equipped with a two-stage Elesco superheater, and interstage reheater, economizer and regenerative-type air preheater. Four bowl mills supply the tangential burners which are of the tilting type.

The second section, which will be practically a duplicate of the first, is scheduled to go into service in 1953, and a third of 125,000 kw is expected to be ready late in 1954.

Dedication Exercises

Speakers included Frank J. Lausche, governor of Ohio, Carl W. Rich, mayor of Cincinnati, G. A. Price, president of Westinghouse Electric Corporation, which built the turbine-generator, and Joseph V. Santry, president of Combustion Engineering — Superheater, Inc., which built the boiler, and Walter C. Beckjord.

Mr. Price paid a tribute to the economic planning which goes into such a plant—planning based on the experience of experts in the field. Such planning, he said, lies at the heart of our economic system which has been under constant attack from the "political left." He observed further that, although some of our political leaders pay lip service to free enterprise, they unblushingly demand nationalization of public utilities. Now is the time, he believed, to turn a spotlight on newspaper columns, magazines and lecture platforms that are used to preach socialism in the utility field. He urged that every unfair and uninformed attack on the concept of free enterprise in the utility field be identified for what it is and answered accurately.

Mr. Santry recalled it was just 70 years ago that Edison started his Pearl St. Station in New York, the first electric central station in the world, and thereby launched our country on an era of economic progress that has made it the most powerful and prosperous nation. In fact, with only 5 per cent of the world's land area and 7 per cent of its people, America produces about half the total electricity.

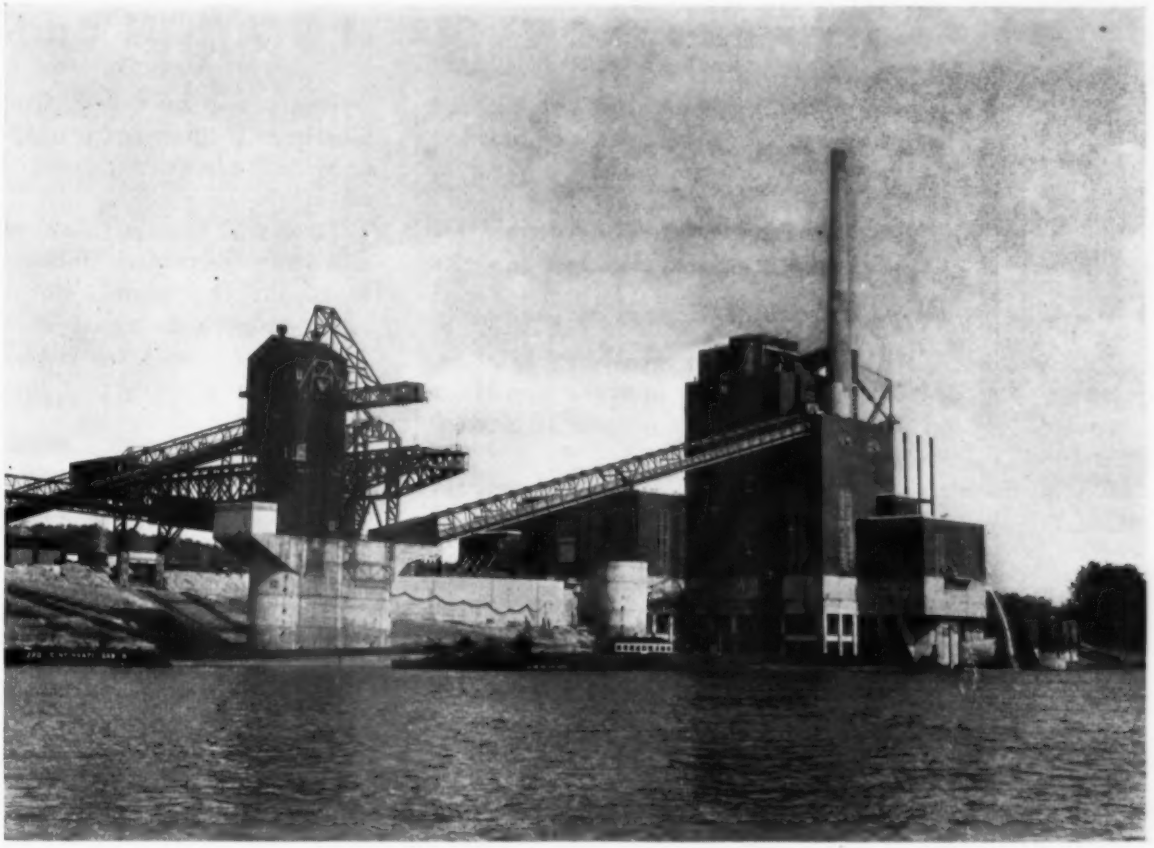
The Beckjord Station, he observed, embodies the latest advances in power equipment which should be reflected in an exceptionally low heat rate

As a tribute to Walter Beckjord's role in this project, Mr. Santry pointed out that, although it couldn't have been brought to completeness without the effort, skills and experience of many individuals, behind such a project must lie the vision and courage to undertake it, together with the competence to make many major decisions, and the leadership to bring it to a successful conclusion. These were supplied by Walter Beckjord.

In his dedicatory address, Mr. Beckjord traced the history of the Company which started as a gas company and subsequently became one of the early groups to go into the electric generating business. Its first station was built on Plum Street, at the bend of the old Miami and Erie Canals and was gradually expanded from a small beginning up to 40,000 kw at the time it was abandoned. In 1918 the West End Station was placed in operation with an initial capacity of 50,000 kw which over the years was increased, by redesign and topping units, to a present capacity of 214,000 kw. The Miami Fort Station, which began operation in 1925 with 90,000 kw, now has 356,000 kw.

At the beginning of World War I the company's total capacity was 40,000 kw; by the end of World War II this had increased to 430,000 kw; and today it is 660,000 kw. When the two additional units now under construction for the new station are completed, the total generating capacity of the company will be approximately 900,000 kw.

Mr. Beckjord observed further that the Cincinnati Gas and Electric Company is an entirely independent company and that the new station has been built without the aid of any government planning, subsidy or assistance. In other words, it represents an accomplishment of free enterprise.



First section of the Walter C. Beckjord Station

Two 1250-psi, 950-FTT C-E-S radiant type boilers fired with pulverized coal or oil, each 400,000 pounds per hour. Soot blowing by steam, with air-powered long retractables, rotary units, wall blowers and air-heater blowers under Vulcan Automatic-Sequential Control.

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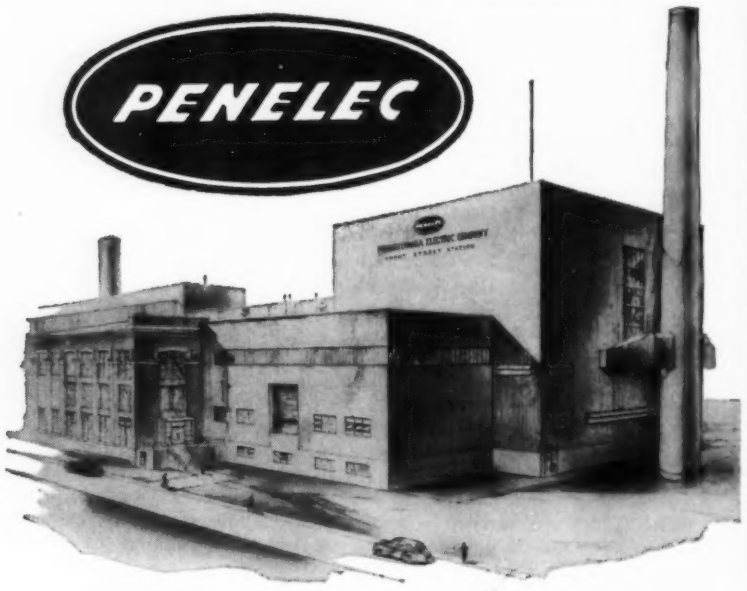

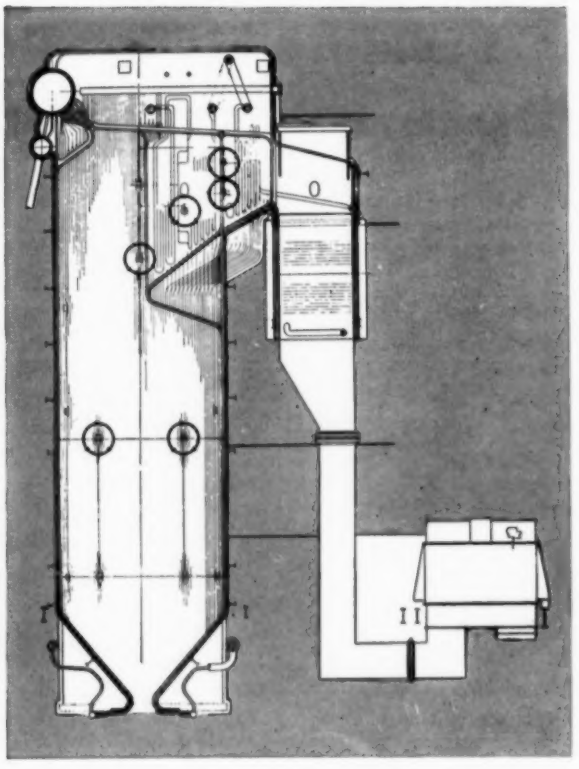

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Metals and Metal Processing in the Atomic Energy Field

By ALAN U. SEYBOLT

Knolls Atomic Power Laboratory

Work in the field of nuclear energy has involved a number of the newer metals about which much is being learned. Although so far they have very little, if any, application to the conventional power plant field, they are certain to play an important part in such nuclear power as may ultimately result from present developments. The following is from a paper presented at the recent ASME Semi-Annual Meeting.

IT is the object of this brief review to outline some properties of a few of the "newer" metals of more or less interest in the Atomic Energy Program and also to describe some of the processes used in manufacturing or fabricating these metals. While there are probably few potential applications of these materials or processes to other fields at the present time, there may be some future applications, and in any case it is hoped that the mechanical engineer will get some feeling for some of the current A.E.C. work.

Zirconium

Much that has been written in recent years on the subject of titanium applies to its sister element zirconium. The two metals are closely similar in properties, both chemical and physical, but zirconium is more dense, 6.5g/cc vs 4.5g/cc for titanium, (0.23 lb/in.^{3} vs 0.163 lb/in.^{3}) hence it is not so desirable structurally since the strengths of the two pure metals are practically the same.

Zirconium metal is prepared by magnesium reduction of gaseous $ZrCl_4$ at the Albany Oregon station of the Bureau of Mines. Like the titanium process, this method was developed by W. J. Kroll, according to whom it should sell for the same price as titanium if manufactured on the same scale. At present, titanium is somewhat cheaper because of larger production. Present costs are about $7 per lb for zirconium ingot in the Bureau of Mines plant.

Unlike most metals which can be melted in the air in ceramic crucibles or ceramic-lined hearths, zirconium must be melted in vacuum or in a noble gas in pure graphite crucibles or by an arc furnace in a water-cooled metal mold.

The latter method is preferred because of undesirable carbon contamination which lowers the ductility of the metal somewhat without increasing the strength sufficiently to compensate for this. A disadvantage of the arc melting process is that the metal cannot be poured into a mold of some desired shape, but must be melted and cast in place, usually in the form of a solid cylinder 2 to 8 in. in diameter and as long as desired. Alloying of the zirconium and the mold wall is prevented because the latter is effectively water-cooled. Ceramic crucibles such as MgO, Al_2O_3, ZrO_2, etc., cannot be used, as molten zirconium reacts with every known high temperature material. Another difficulty in this melting technique is that since the ingot is melted and cast layer by layer, the control of alloying additions such that a uniform distribution through the cast structure is obtained is difficult. However, by improved techniques this trouble is minimized and it is not actually holding up progress at present.

Physical Properties of Zirconium

Density	6.5 g/cc
Melting point	1830 ± 40°C
Allotropic modifications—	
alpha (hexagonal close packed)	up to 863°C
beta (body centered cubic)	863°C—m.p.
Thermal expansion (linear)	5.2 × 10^{-6}/°C
(varies somewhat with direction measured)	2.9 × 10^{-6}/°F
Thermal conductivity	0.035 ± 5% cal/-cm²/sec/°C
Electrical conductivity	4.1% of IACS Copper standard 20°C

Mechanical Properties of Bureau of Mines Zirconium

Condition	Area %	Elongation % (2")	0.1% Offset Yield Strength 1000 psi	Ultimate Strength 1000 psi
Extruded at 800 C (probably nearly equivalent to annealed)	44	15	43	80
Strength at 500°C	..	50	10 (0.2% offset)	20
Rockwell B hardness	80			
Young's Modulus	11.3 × 10^6 psi (high purity metal)			
Poissons ratio	0.3(?)			

Like all hexagonal close packed metals, zirconium shows a high degree of preferred orientation in the wrought state, such that properties measured along the length of a rod may be appreciably different from those measured in a direction at right angles to the rod axis.

Unfortunately, at the present there is very little strength data at elevated temperatures available.

Corrosion Resistance

One of the most attractive features of zirconium is its excellent corrosion resistance to many media, at least at low to moderate temperatures. It is quite stable in ordinary air atmospheres and to boiling water. It is resistant to acids except for HF and very concentrated H_2SO_4 and H_3PO_4. In water at 260 C (500 F) and 700 psi, it stands up better than 2S or 72S aluminum. However, at temperatures above 300 C it reacts with increasing vigor with all gases except the noble gases, such as argon and helium. It absorbs hydrogen very rapidly at temperatures near 800 C to form the hydride, ZrH_2, and at this temperature level absorbs large quantities of oxygen and nitrogen, taking up oxygen more rapidly than nitrogen. All three gases embrittle the metal but hydrogen is the only one which can be removed (by vacuum annealing).

Alloying Possibilities

Like iron which has an allotropic change at 910 C zirconium has one at 863 C where the hexagonal close-packed lower temperature modification changes to the higher temperature body centered cubic form. Such transformations are accompanied by drastic changes in solubility of alloying metals which, in turn, lead to interesting alloying possibilities. It is the large change in carbon solubility at the transformation temperature in iron which makes possible the heat treatment and hardening of steel. It is not unreasonable to expect that the transformation of zirconium should make possible the development of some interesting alloys. However, the alloy development of zirconium is just starting, and it may be 2 or 3 years before any proper appraisal of alloying possibilities can be made.

Beryllium

Most of the pure beryllium produced in recent years has been made by magnesium reduction of BeF_2. The as-reduced metal is mechanically separated and washed from the MgF_2 formed in the reduction reaction, is vacuum melted to further separate it from impurities, and is then crushed into powder. The reduction to powder is carried out in an inert atmosphere closed system to reduce surface oxidation and to protect the operators from berylliosis, a silicosis-like condition for which there is at present no certain cure, and which can be caused in some people by breathing-in fantastically small amounts of beryllium or its compounds. Beryllium is generally fabricated by powder metallurgy methods because as melted and cast it has a large grain size, leading to inferior mechanical properties. By the use of powder metallurgy techniques, it is possible to keep the grain size small and to obtain a dense product capable of being machined to close tolerances, and which has optimum mechanical properties.

SOME PHYSICAL PROPERTIES OF BERYLLIUM

Density	1.86 g/cc
Melting point	1280 C
Thermal expansion (20°C–700°C)	16.8×10^{-6}/°C
Thermal conductivity (455°F 235°C)	75 Btu/hr/ft²/-°F/ft
Electrical resistivity	4.3×10^{-6} ohm-cm

The mechanical properties of beryllium are very poor because of lack of ductility and because of notch sensitivity. While with a sufficiently small grain size and a high degree of preferred orientation (as by extrusion of a rod) the ductility may be adequate in the longitudinal direction, it is very low in the transverse direction. The per cent elongation for hot-pressed powder, which is nearly isotropic, is about 1 per cent in 2 in. and the 0.2 per cent yield strength and the ultimate strength are about 30,000 psi and 40,000 psi respectively. The per cent elongation of extruded rod, on the other hand, may be as high as 20 per cent along the rod axis. Young's modulus is quite high, about 40,000,000 psi.

No promising high beryllium alloys have been developed, and the prospects for such a development look rather dim.

Sodium

A few years ago about the only engineering use of sodium was in aircraft engine valves, where it is used to cool the valve surface by transferring heat to the stem by splashing back and forth inside the hollow valve. Today the engineering know-how on the use of sodium as a heat-transfer medium is quite extensive because of the large amount of effort expended on its use for cooling nuclear reactors. This study has proved sodium to be a practical and efficient heat-transfer medium, whose use will undoubtedly be extended to many engineering applications.

Some of the advantages of sodium as a heat-transfer fluid are (1) high specific heat; (2) low density; (3) low melting point of 208 F; (4) high thermal conductivity; (5) low film drop; (6) non reac-

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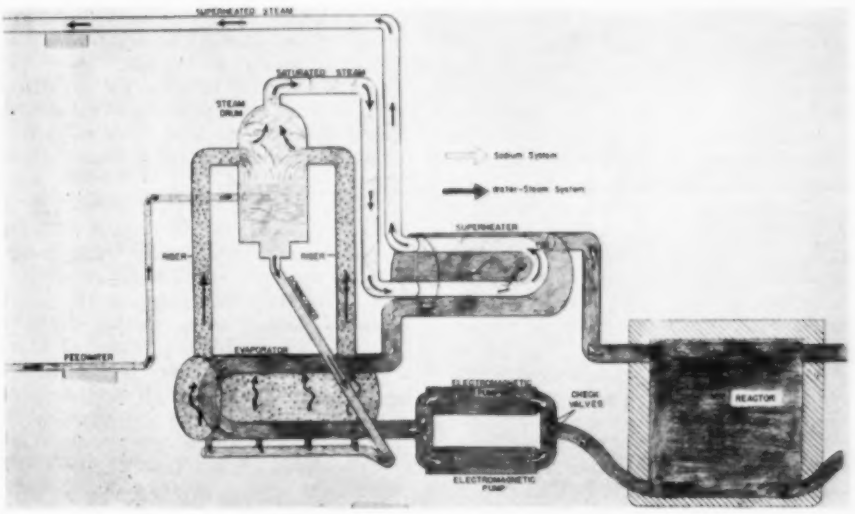

Schematic nuclear power plant layout employing sodium

tive to 18-8 austenitic stainless steel; (7) fairly high boiling point of 1621 F; and (8) low vapor pressure.

Because of sodium's high specific heat and low density, it is economical to pump and more heat is removed per pound pumped than by any other liquid metal except lithium.

At the Knolls Atomic Power Laboratory, an oil-fired sodium heat-exchanger unit has been in continuous operation for several years in which 300 gal of sodium per minute are pumped. In this unit the highest outlet temperature is 950 F while the corresponding inlet temperature is 600 F. Although pure sodium is not corrosive to most high melting metals such as iron, zirconium and stainless steel, sodium oxide is quite corrosive and should be present at a very low level. Because of the ease with which sodium oxidizes or actually burns in air, the metal must be melted and handled under a blanket of inert gas, such as helium. Also, because the freezing point is above room temperature, all piping through which it is transferred by pumping or by inert gas pressure, must be heated by wrapping with resistance heating wire or the equivalent, and thermally lagged.

While mechanical pumps have been successfully used for sodium, a rather unique type of pump has been designed for use with it which makes use of the fact that sodium is an electrical conductor. This is the electromagnetic pump in which the sodium being pumped acts like the rotor of an induction motor. Pumps of this type have the advantage that no shaft seal problem is encountered since no opening into the flowing sodium is required.

Herewith is a schematic drawing of a heat-exchange system for a liquid metal cooled nuclear reactor, such as proposed for a power plant.

Processes

MELTING AND CASTING

The atomic energy program, because of the importance of chemically active metals like zirconium, has necessitated the development of special techniques for handling these materials. Before the war vacuum melting was a relatively unimportant technique used by a few research metallurgists to prepare a few grams of highly pure alloys for research purposes. While the comparatively large use made today of vacuum melting cannot be ascribed entirely to developments in the atomic energy field, it is nevertheless true that a large amount of know-how in this field was forced in the "hot-house" of the Manhattan District. Gas-free common metals are now available for electronic and other applications where high purity and freedom from dissolved gases are important.

Some metals, like zirconium, cannot be melted in ceramic crucibles because of excessive reaction with the crucible. For metals of this class, which include zirconium, titanium and vanadium, arc melting with inert atmosphere in a water-cooled metal crucible is used. The melted metal cannot alloy or stick to the metal crucible since it is kept cold; a thin layer of solid metal prevents actual molten metal-crucible contact. This method has proved to be the best technique for preparing large commercial titanium and zirconium ingots for further processing.

METAL FABRICATION

Metals of this class cannot be heated for extended periods in air because of their tendency to absorb both oxygen and nitrogen, hence annealing and working operations on thin sections must provide for protection from the atmosphere. While it is true that titanium and even zirconium may be successfully heated in an air furnace and brought out into the room red hot and forged or rolled, it is also true that such operations are conducted on fairly thick sections which are later scalped or pickled to remove the layer of embrittled metal. On operations dealing with thin strip or drawn tubing where the thicknesses are only a few thousands of an inch, the fabrication and heat treatment must be handled in a

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different manner. Vacuum or possibly salt bath annealing are possible techniques and if hot work is required, cladding in a metal of similar working characteristics such as mild steel or copper are methods which have been successfully used to prevent atmospheric attack.

Zirconium tubes are produced by extrusion at 1500 F with the billets clad in copper to protect the metal during the heating cycle as well as during the extrusion operation itself. The copper is subsequently removed by acid pickling.

Thin Walled Stainless Steel Tubing

Another example of new process techniques instigated by a need which arose in atomic energy work is the development of methods for producing 18-8 stainless steel tubes 2 in. in diameter by 0.010 in. thick wall. Several tube companies were contacted in regard to supplying this item, but the uniform answer was that this shape was outside the commercial range. One company offered to attempt to produce such tubes on a development basis, and after a few months of experimenting were eminently successful in producing what they termed stainless steel "beer cans."

Welding of Thin Walled Tubes

Thin-walled tubes, of which one size was mentioned in the above paragraph, are of particular interest in nuclear engineering because of the necessity of reducing to a low level the number of foreign atoms such as those in structural members. Considerable effort at the Knolls Atomic Power Laboratory has been expended in developing techniques for inert arc welding of very thin wall tubes to various closures and in making joints involving all ratios of thickness. Methods have been developed for making gas-tight joints in tubes of stainless steel, mild steel, nickel, titanium, molybdenum and Fernico. Many of the thin members have been in the range of 0.004 in. to 0.032 in. thick, and have been made tight to leak rates of 10^{-8} cc of helium per second or a leak of 3 cc in 10 yr, as determined by a Type M mass spectrometer leak tester using a helium probe.

Among the conclusions reached were that zirconium-oxide-coated or thoriated-tungsten electrodes resulted in a more stable arc. Sounder welds in nickel were obtained using an 80-20 argon-hydrogen gas mixture rather than pure argon. Argon was preferable to helium when welding very thin sections of type 347 stainless steel, because helium developed excessive heat.

Powder Metallurgy

The application of powder metallurgy has already been mentioned briefly in connection with the fabrication of beryllium shapes. Beryllium affords a spectacular example of powder metallurgy since very large beryllium shapes have been prepared by pressing beryllium powder at temperatures near 1100 C in vacuum. Rectangular blocks approximately 30 in. wide by 50 in. long by 4 in. thick of nearly full density have been prepared in this manner by the Brush Beryllium Company. Large cylinders 12 in. in diameter by 4 in. thick have been made in a similar manner by pressing in air.

While the potential application of beryllium itself is very limited, the hot-pressing technique is not. It has been used to prepare large billets of magnesium and aluminum by pressing the metal powder close to the melting point in graphite dies using a pressure of about 1000 psi. The advantage of this method is that insoluble additions such as oxides or relatively insoluble metals may be incorporated in the aluminum structure, which would merely float to the top if melted in the regular manner. Some Swiss investigators have recently discovered that extremely fine aluminum powder in the sub-micron region when pressed into a solid bar has a creep strength superior to the best aluminum alloys. The superiority is presumably due to an oxide coating on the powder particles such that the final composition has several per cent Al_2O_3.

As a variant of regular powder metallurgy techniques, the direct consolidation of powder into a fabricated shape by extrusion looks interesting. This method by-passes the billet stage and allows the formation of a rod or tube without an intermediate product. The extrusion process simultaneously compacts the powder and forces it out through a die of appropriate shape. Here again, this method is particularly valuable when a special structure unobtainable by melting is necessary. Such extrusions have been made using metal-oxide mixtures high in metal content when the metal has been aluminum, magnesium or nickel. Naturally, it is not limited to these metals, but it offers a technique of preparing extruded shapes of the so-called "cermet" type where a mixture of a ceramic material and a metal is used.

Combustion Symposium

Plans have been announced for the 1952 International Symposium on Combustion, to be held at Massachusetts Institute of Technology, September 1 to 5.

Since the last symposium in 1948, the accelerated pace of combustion research has yielded important new knowledge, much of which will be presented at the symposium in some 100 papers from Great Britain, France, Holland, Belgium, Germany and Japan as well as from the research laboratories and educational institutions of the United States. At least 50 foreign experts will attend.

Emphasis is being placed on the physical aspects of combustion, particularly wave phenomena and turbulence, treated from both experimental and theoretical standpoints.

Typical fields in which papers will be presented are ignition; stabilization in laminar and turbulent flow; limits of inflammability and detonability; instability phenomena; microstructure of combustion waves; theory of flame propagation; flame-jet structures; and combustion processes in rocket systems.

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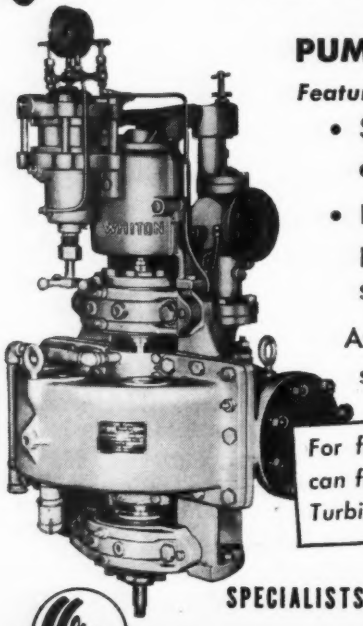

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Increases in Capacity and Energy Output

The Federal Power Commission's report on electric energy production and fuel consumption by utilities during the month of April has recently become available. The data show a total net output for the month of slightly over 31-½ billion kilowatt-hours, which was the highest April production of record. Output of hydro plants was 31.6 per cent of the total and that by fuel-burning plants was 68.4 per cent.

For the twelve months ending April 30, 1952, the total output was 380,677,252,000 kwhr, which was an increase of 10.2 per cent over that for the year ending April 30, 1951. It was the highest total attained during any twelve-month period to date.

Coal consumption by electric utilities during April 1952 was in excess of 8 million tons which was an increase of 2 per cent over that of April 1951, whereas the consumption of fuel oil showed a marked decline, it being 12.6 per cent below that of April 1951. On the other hand, the consumption of natural gas showed a gain of 13 per cent, up to 66,496,630 Mcf.

The indicated average April rate for coal only was 1.09 lb per kwhr compared with 1.15 lb a year earlier. This decrease reflects the influence of the number of large new stations that were put into service during the year and particularly the employment of the reheat cycle in many of them.

Coal Stocks Built Up

Coal stocks on hand at electric utility power plants on May first amounted to approximately 38-½ million tons. In terms of days' supply, based on the rate of consumption for the mouth of April, this represented sufficient coal to last 144 days. This figure compares with 132 days' supply on hand a year earlier. This, of course, represents an average figure.

Fuel oil stocks in the hands of utilities also have been built up to over 12-½ million barrels—a very substantial increase over the 10.6 million barrels of a year earlier, and enough to meet at least 90 days' requirements, based on April use.

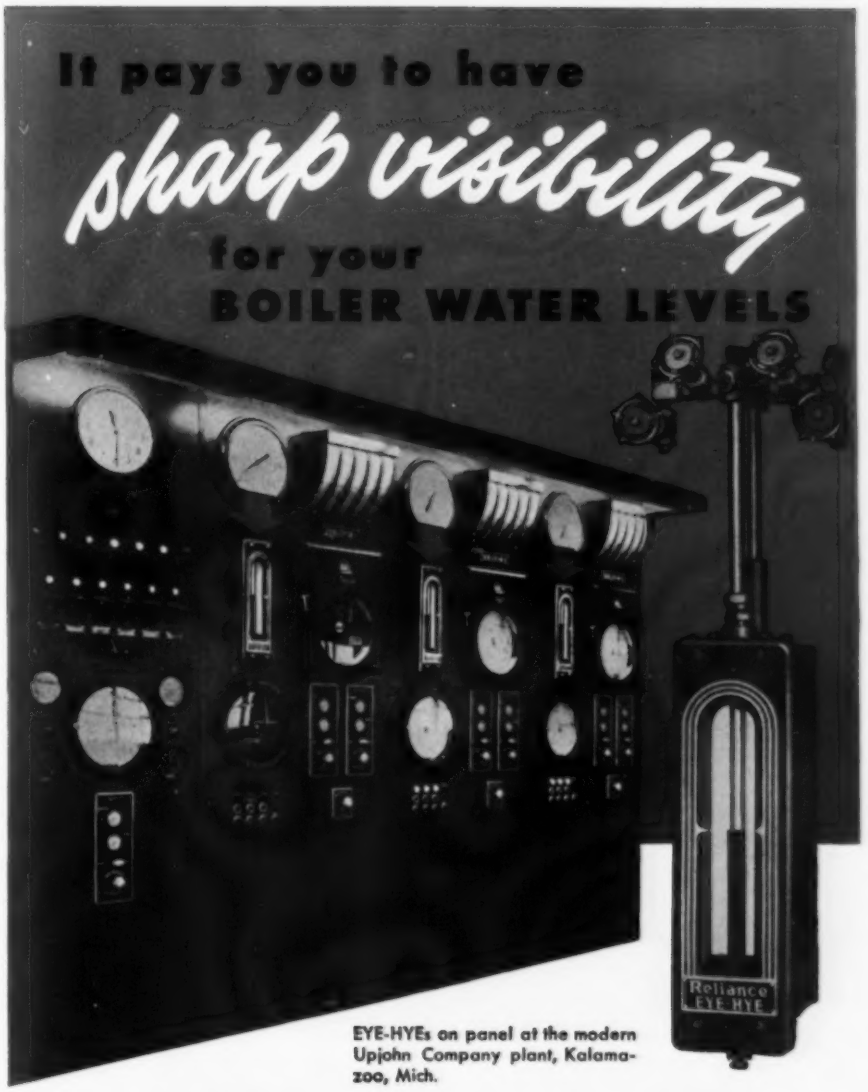
Viewed in the light of the ever-increasing use of natural gas and these substantial coal stocks it would appear that the utilities are well prepared to meet unforeseen emergencies.

The report also covers returns from some 800 industrial generating plants representing about 85 per cent of the total industrial output of electric energy in the United States, extended to represent 100 per cent coverage. Such plants produced 5.2 billion kilowatt-hours during the month —an increase of 1.6 per cent over that for April 1951.

Thus the combined utility and industrial production of electric energy amounted to 36.7 billion kilowatt-hours in April 1952, or 6.7 per cent above that for the corresponding month a year earlier.

Installed Capacities

The installed electric generating capacity in utility service, as of April 30, 1952, is given as 76,736,358 kw and that of the industrial power plants as 14,487,199 kw;



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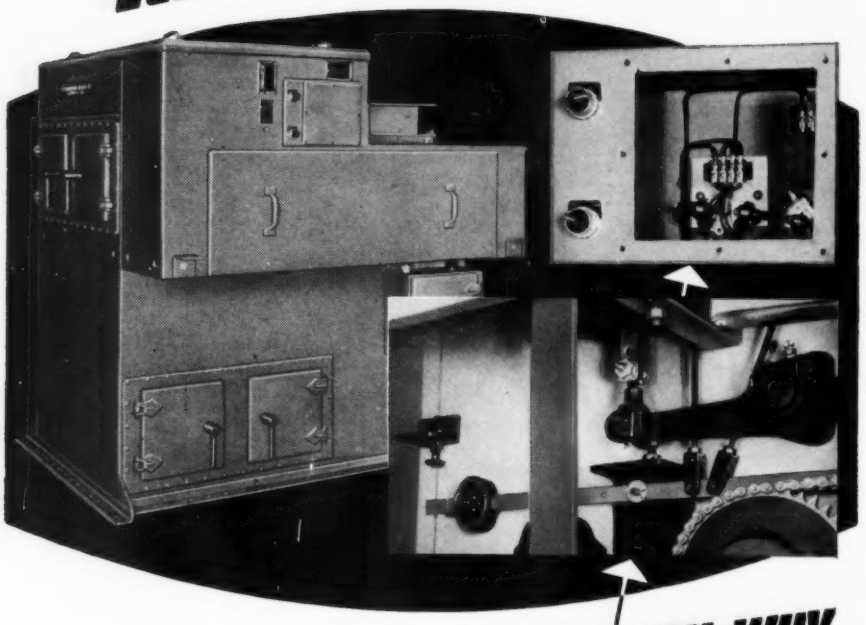

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Standards of Temperature

As a result of the increasing need for reliable temperature measurements at both very high and very low temperatures, the National Bureau of Standards is extending its temperature standardization program toward the extremes of the temperature scale. New instruments and methods of calibration are being developed for these regions, and research efforts are being directed toward the extension of the International Temperature Scale to provide greater accuracy and reproducibility in the measurements thus made possible. The program covering this work is described in technical report No. 1677 by R. E. Wilson, chief of the Temperature Measurements Section of the Bureau.

While the accurate measurement of temperature has long been of interest to the research scientist, its importance, particularly at the extreme ends of the scale, has greatly increased with the rapid technical developments of recent years. During this period, many improvements in processes for the production of steel, glass, gasoline, and other important commodities have resulted from the increased precision that is being attained in the measurement and control of temperature. In aeronautics there are new temperature problems in connection with the use of jet propulsion and the operation of aircraft at high altitudes and in polar regions. To attain the desired performance in jet engines, fundamental research is required to develop methods of measuring temperatures of flames and to develop temperature-sensitive devices for indicating performance and controlling operation. For use at jet-engine temperatures as well as in arctic cold, mechanical parts must be specially designed using materials capable of withstanding these extremes in order to function satisfactorily. Likewise, as a result of the applications of atomic energy, it has become necessary to learn more about the heat-transfer properties of a variety of materials at increasingly high temperatures. For effective research in these fields, temperatures must be accurately measured, and the results of one laboratory must be comparable with those of another.

To provide a fundamental basis for precise temperature measurements, a scale of temperature has been established which covers the range from the boiling point of oxygen to the highest temperatures of incandescent bodies and flames. This scale, known as the International Temperature Scale, is based on six reproducible equilibrium temperatures, or "fixed points", to which numerical values are assigned, and upon specified interpolation formulas relating temperature between or above these points to the indications of standard temperature measuring instruments.

The International Temperature Scale was first adopted in 1927 to provide a scale which would conform as closely as possible to a thermodynamic scale proposed many years earlier by Lord Kelvin. That which he proposed was based on a

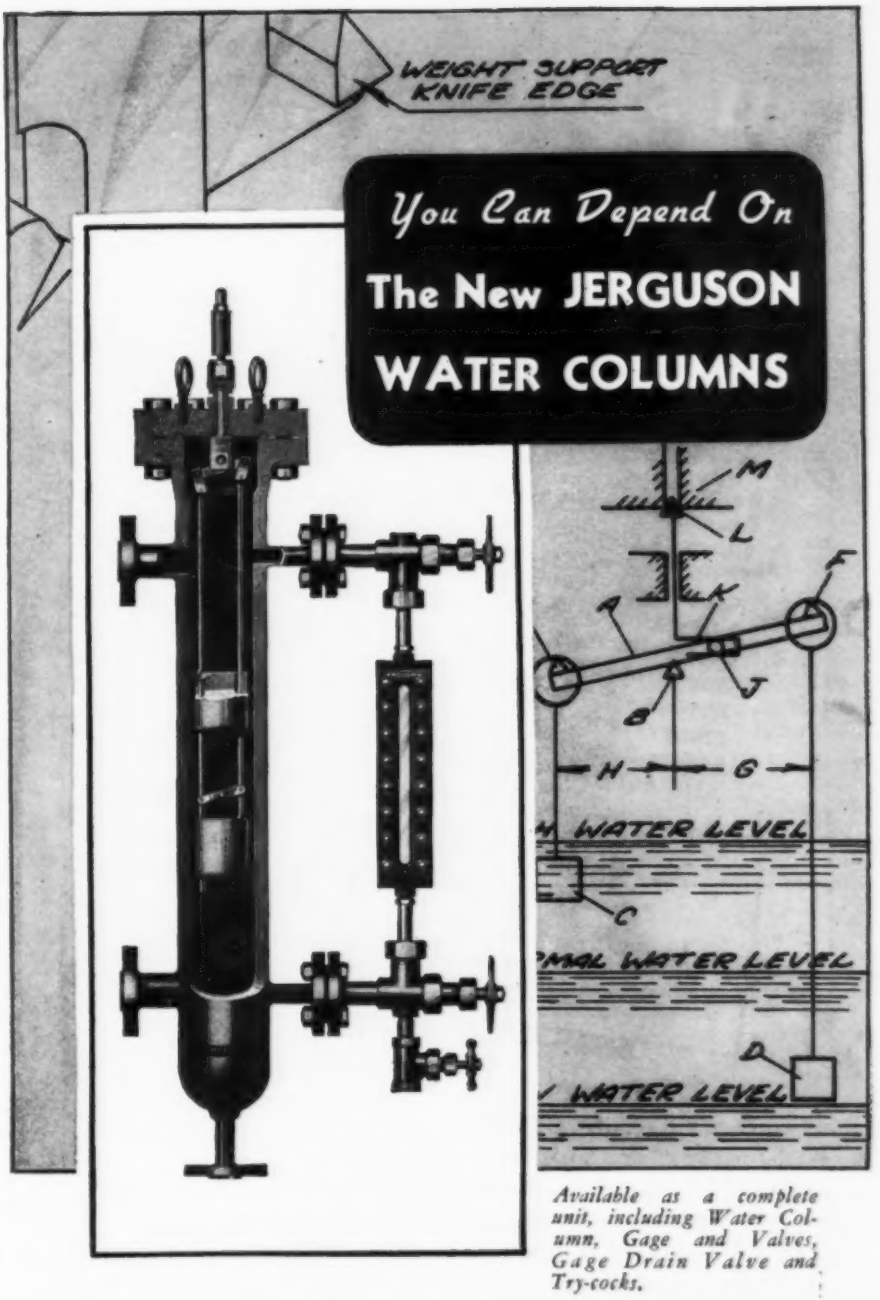
relation between the efficiency of a reversible heat engine and the temperatures between which the engine operates. This scale is independent of the working substance in the engine. Temperatures on this scale are identical with those appearing in the ideal gas law and other thermodynamic relations. By observing the change of pressure with temperature of a constant volume of gas, or the change in volume of a quantity of gas under constant pressure, and applying a correction for the imperfection of the gas, temperatures on the thermodynamic (Kelvin) scale can be determined. In practice, however, the complexity of an accurate gas thermometer and the difficulty of making highly precise measurements with it are severe limitations on its use.

The experimental difficulties involved in measuring temperature on the thermodynamic scale and the importance of measuring temperature with high precision on the same scale in all countries ultimately led to the establishment of the International Temperature Scale of 1927. This scale, proposed by the national laboratories of the United States, Great Britain and Germany, and adopted by 31 nations, was designed to conform as nearly as practicable to the thermodynamic scale as it was then known. It has always been possible to obtain values of temperature on the International Temperature Scale more accurately than on the thermodynamic scale.

The International Temperature Scale of 1927 proved useful in providing a stable, uniform, and precise basis for obtaining temperatures. However, in the 20 years following its adoption, the increasing precision attained in temperature measurements made it apparent that some revision was desirable in order to make the scale more self-consistent and to improve its agreement with the thermodynamic scale. The major responsibility for proposing and obtaining agreement on the changes fell to the National Bureau of Standards. After many consultations with scientists and laboratories in this country and abroad, the Bureau prepared a draft that formed the basis of the document finally adopted at Paris by the Ninth General Conference on Weights and Measures as "The International Temperature Scale of 1948" (1, 2). On January 1, 1949, the Bureau began using the definitions of the 1948 scale, both in its own research program and in calibrating instruments for other scientific and industrial purposes.

The six fixed points of the 1927 scale were the boiling point of oxygen (−82.97 C) the freezing and boiling points of water, the boiling point of sulfur (+444.60 C), the melting point of silver (+960.5 C), and the melting point of gold (+1,063 C). From −190 C to +660 C, the measurement of temperature was based on the indications of a standard platinum resistance thermometer used in accordance with specified formulas; from +660 C to the gold point, the platinum versus platinum-10 per cent rhodium thermocouple was standard; and above 1063 C, the optical pyrometer was used.

The same fixed points, with one slight modification, are specified in the 1948 scale.



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Atomic Engine for U. S. S. Nautilus

Under contract with the Atomic Energy Commission and the Navy Department, the Westinghouse Electric Corp. is building both the nuclear reactor and the associated propulsion equipment for the *U. S. S. Nautilus*, atomic-powered submarine whose keel was laid June 14 at Groton, Conn., at ceremonies attended by President Truman and many distinguished guests. The submarine will be built by the Electric Boat Division of the General Dynamics Corp.

Although the work has been cloaked in secrecy considerable progress is said to have been made. Research, design and production work still is going on at the Bettis Field site near Pittsburgh and a "land-based prototype" of the atomic engine is being built at the National Reactor Testing Station near Arco, Idaho.

This land-based prototype consists of a nuclear reactor, all its controls, the water for extracting heat from the reactor, and the means for converting this heat energy to power. The steam propulsion system follows marine practice except for measures taken to reduce dimensions and weight.

One of the toughest problems of design of this nuclear power plant, was to find suitable materials with which to construct the reactor core. These materials must have the proper strength at the operating temperatures, they must not deteriorate under intense radiation and they must not absorb too many of the precious neutrons. Every material used, every part built, must be examined with great care in the light of the unusual operating conditions. This means the analysis of behavior of conventional materials and also of strange new materials when they are exposed to nuclear radiation, and when they encounter other heretofore unknown conditions.

Classified models and full-scale mock-ups, many of transparent plastic, set up at the Argonne National Laboratory and at Bettis Field, have been of invaluable help in determining how well parts go together and also in enabling the engineers and technicians to visualize the mechanical elements, many of them the first of their kind.

Obituaries

Cecil C. Willis, superintendent of generation for the Oklahoma Gas and Electric Company during the last eleven years, died on June 27 from a heart ailment. He was 53 years old and became associated with that company shortly after graduation in mechanical engineering from the University of Kansas in 1922. He was a member of the American Institute of Electrical Engineers.

Frank L. Harris, chief draftsman of the C. H. Wheeler Company, Philadelphia, died suddenly on June 15. He had been with that company for more than 25 years and had an important part in condenser design and sales. His wife and two daughters survive.

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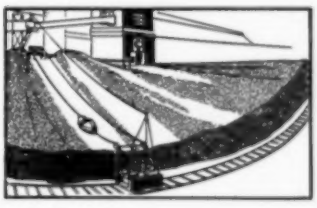

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● *The Sauerman Scraper installation pictured above utilizes a simple monorail to shift the path of the scraper. Larger installations use a self-propelled tail tower as sketched at left. For small stockpiles, a scheme of manual shifting is available.*

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Engineers Preferred for Top Industrial Jobs

Engineers are preferred for top management jobs in industry, but to make the grade they must possess creativeness and initiative, electrical engineers were told at the recent summer meeting of the AIEE in Minneapolis. The speaker, C. M. Hines of Westinghouse Air Brake Company, elaborated on this assertion by pointing out that creativeness implies innate curiosity, a seeking for new things, or better, more efficient ways of obtaining desired results, and ability to get off the beaten path; whereas the second quality, initiative, is the "explosive mixture ignited by the spark of creativeness and supplies the energy to convert ideas into things."

Mr. Hines added further that it is obvious an engineer cannot assume the responsibilities of a general management executive unless he first demonstrates his ability to accept broad responsibilities in the engineering profession. He cited the results of a Columbia University survey which revealed that 41 per cent of all top management executives in the United States are engineering graduates. Also, another survey had shown that 92 per cent of a large group of industrial firms consider professionally trained engineers as potential general management executives.

Newly elected president and two new members of the board of directors of the Air Pollution & Smoke Prevention Association of America. From the left: R. E. Nicholls, Chief Smoke Inspector, Windsor, Ontario; James H. Carter, Commissioner of Smoke Regulation, St. Louis, the new president, and W. H. Carter, technical engineer of power plants for The Detroit Edison Company

NEW CATALOGS AND BULLETINS

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Conveying Equipment

A 28-page booklet, No. 2475, containing information and photographs of Bulk-Flo conveyors and elevators has been published by Link-Belt Co. Besides showing typical layout drawings, calculation tables and engineering data, the bulletin includes a tabulation of more than 150 materials which are analyzed for average weight and such characteristics as size, flowability and abrasiveness.

Gages and Valves

Jerguson Gage & Valve Co. has prepared a four-page data sheet on heated and cooled gages and valves. There is a tabulation of pressure groups for which this equipment is available, along with diagrammatic sketches and typical materials used.

Protective Coatings

Technical bulletin sheet No. 501 issued by Prufcoat Laboratories, Inc., provides potential users with the resistance ratings of Standard Series, "A" Series and Prufcoat BX white enamel to some 69 corrosive chemicals. The tabulation is based on what are considered reliable data from both laboratory tests and practical field applications.

Vacuum Deaerator

A colorful eight-page bulletin (No. 3698) describing a vacuum-type deaerator has been compiled by The Permutit Co. The bulletin outlines how the apparatus removes oxygen and free carbon dioxide from water so as to protect piping, steel tanks and other equipment from the harmful effects of corrosion.

Phosphatizing Treatment

Rustshield 2, a chemical treatment that produces an oil-retaining rustproof surface for moving metal parts, is described in a four-page publication by Octagon Process, Inc., of Staten Island, N. Y. This two-color booklet discusses application methods and advantages of using this material on sliding and bearing surfaces.

Mono-Bed Demineralizer

A new catalog sheet giving a clear and concise description of a new mono-bed demineralizer has been made available by the Penfield Mfg. Co., Inc., of Meriden, Conn. It includes a picture of the unit, a diagram with parts lettered and identified, a description of the parts and specifications and performance charts. This unit is available in flow rates from 10 to 10,000 gph and reportedly has processed water having resistances as high as 20,000,000 ohms per centimeter.

Rotary Pumps

De Laval Steam Turbine Co. has released a four-page bulletin, L313B, on Imo pumps nesigned for continuous operation up to 275 psig at capacities as high as 80 gpm. This is a general service, screw-type rotary pump designed for handling petroleum products and other light viscous fluids such as required for hydraulic systems, rotary and steam-atomizing oil burners, lubrication, governing systems and similar services.

Heat Exchangers

Heat exchangers manufactured by Superior Combustion Industries, Inc., are described in an eight-page bulletin which illustrates the basic components of various types of heat-transfer equipment. Special attention is given to tank heaters and fuel oil heaters.

Reciprocating Pumps

Data Sheet 65A prepared by the Aldrich Pump Co. describes applications, features, design and operation of Aldrich-Groff "Powr-Savr" controllable-capacity pumps. It includes sectional and dimension drawings, ratings and a diagrammatic layout of an automatic hydraulic stroke-control system for boiler feeding, oil-burner supply and similar applications.

Zeolite Softeners

Cochrane Corp. has issued a revised edition of their bulletin, No. 4520-A, on sodium zeolite softeners. It gives a detailed explanation of zeolite water softening, including a glossary of terms used in the process, data for laying out a softening plant, factors governing equipment sizing, and selection of zeolite materials.

Wired Television

Engineers who have become interested in wired television for use in determining water levels, flame condition, and remote vision of other power plant operations will wish to have a copy of Bulletin 1025-A prepared by Diamond Power Specialty Corp. The four-page bulletin describes the new Model 300-B Diamond "Utiliscope," cites its many advantages, and lists typical uses. It also contains limited technical information on the camera tube and circuit design.

Industrial Steam Traps

A new 12-page bulletin, No. 152, prepared by W. H. Nicholson & Co., features steam traps equipped with bronze, monel or stainless steel, and bodies in bronze, semi-steel or cast-steel construction in sizes $\frac{1}{4}$-in. to 2 in., for all pressures from vacuum to 300 psig. Included beside capacity tables and dimensions are recommended piping diagrams, typical applications, tables and data covering the selection of traps for various types of steam-using equipment.

Instrument Transformers

The 1952 edition of the Instrument Transformer Buyer's Guide, containing basic up-to-date information on the complete line of General Electric instrument transformers, has been made available by the Company's Meter and Instrument Department. The fully illustrated, 94-page publication, GEA-4626E, gives ratings, ASA accuracy classifications and prices of all G-E indoor and outdoor potential and current transformers, metering outfits and potential and current portable transformers. Listings of ratio and phase-angle tests, together with tables covering the mechanical and thermal limits of current transformers are also included.

Steam Trap Manual

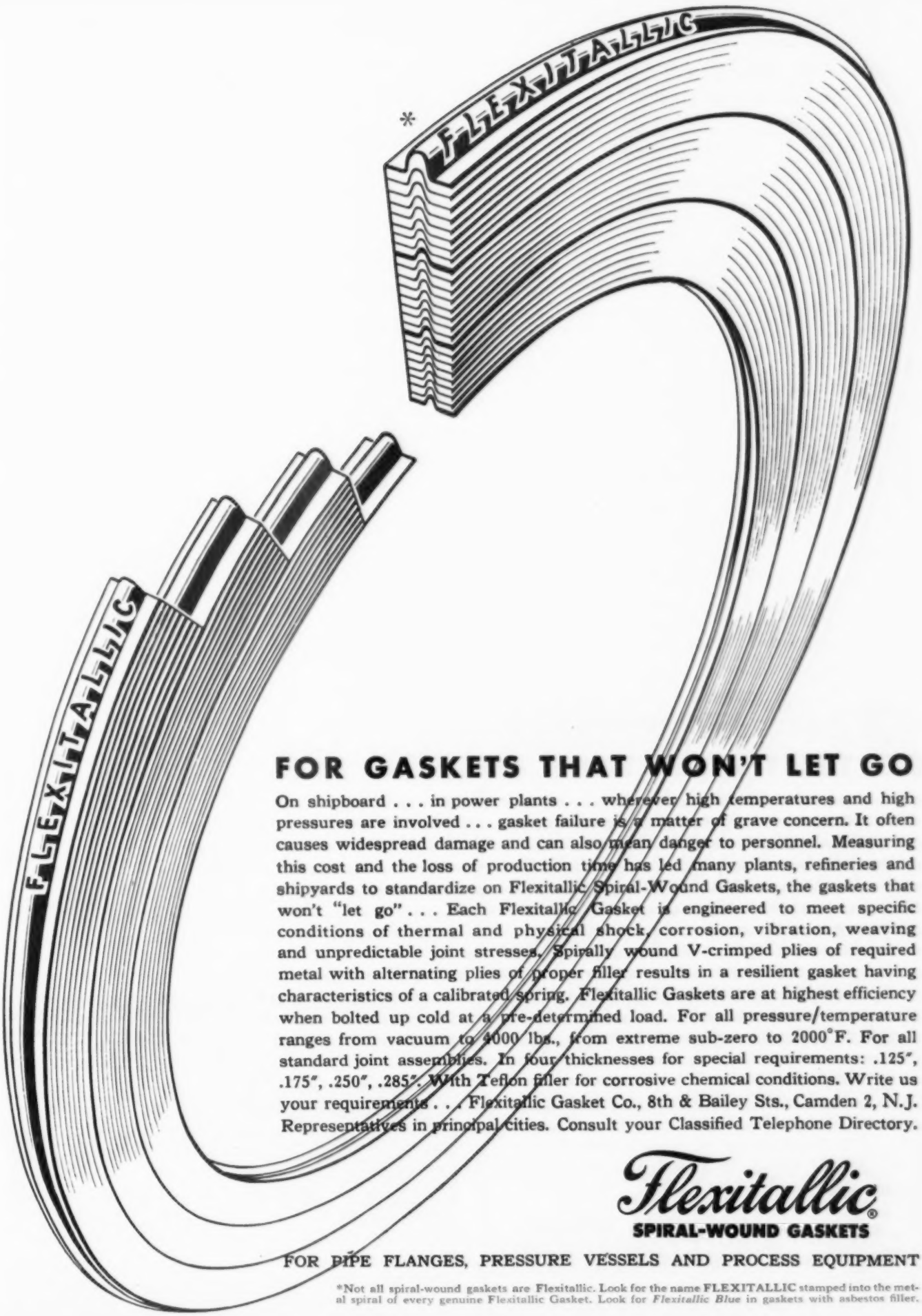
Armstrong Machine Works, Three Rivers, Michigan, has recently issued its new "Steam Trap Book", designated as Catalog J and superseding its previous Catalog H. This 44-page catalog serves as a manual of recommended trapping practice. The publication includes: a trap catalog section containing complete physical data and list prices on Armstrong cast semi-steel and forged-steel inverted bucket steam traps, compound steam traps and ball float air and air relief traps; a handbook section explaining how to calculate condensate loads and select traps for all classes of equipment, and a maintenance section explaining trap installation, preventive maintenance, troubleshooting and repair.

The book is well illustrated with installation diagrams and cutaway and cross-sectional views. Also included are numerous charts and tables relating to the subjects covered. A detailed index simplifies location of subject matter.

Thermocouples

To present its complete line of standard thermocouple assemblies and parts, Leeds & Northrup Co., Philadelphia, has just published a newly-revised and illustrated 44-page catalog,—"Thermocouples–Assemblies, Parts and Accessories"—which not only offers the latest information on available couples and couple assemblies for general applications, but also includes an expanded section on special couples for plant and laboratory.

In a simplified tabular arrangement, the publication lists the accuracy limits of couples, the temperature and physical limitations of thermocouple and protecting tube materials, and the recommended protecting tube and well materials for general applications. The expanded section on special couples includes those for such applications as open-hearth, etc.



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ASEE Meeting Discusses Personal Qualities in Engineering

The importance of the human being was reaffirmed at the 60th Annual Meeting of the American Society for Engineering Education held at Dartmouth College from June 23 to 27.

Dr. C. C. Furnas, Director of Cornell Aeronautical Laboratory, gave knowledge last place in a list of qualities of successful engineers in a speech before the annual banquet of the Society. Ahead of knowledge he placed "drive," "imagination," "judgment," "facility in human relations." The mind also came out last in another Furnas-prepared list where "economic advantage" and "snobbishness" were placed ahead of "intellectual curiosity."

The popular belief that manpower for the professions in the United States is inexhaustible is far from true, Dean S. C. Hollister of Cornell University warned in his presidential address. He pointed out that studies and tests have revealed that only 120,000 youths are available annually who possess the intelligence and ability for professional training for medicine, science, law, theology, engineering and the upper levels of the teaching profession.

Current freshman enrollment of 38,000 in engineering represents just about the maximum of engineering's share of this annual pool of qualified young men, Dean Hollister stated. "If by artificial stimulation a larger number is persuaded to enter engineering schools it will probably be at the expense of enrollments in other fields."

Engineering Aides Suggested

To answer the problem created by a limit in engineering manpower on the one hand and a steadily increasing need for engineering services on the other, Dean Hollister urged the training of more aides to support engineers, as in the case of medicine, and a change in industry's policy of using college-trained engineers for junior administrative work and related activities.

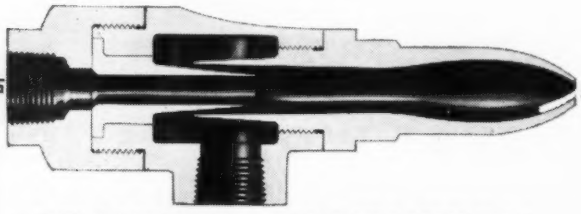
To these two factors which need to be considered in the readjustment of the engineering profession to the needs of today's economic system, Dean Hollister added a third. "It appears that we have reached a turning point in the profession," he said, "where it would seem that a complete reorganization must take place over the next few years if the engineering of the future is to be achieved at the level demanded by our economic system."

Emphasizing that the engineer differs from other professional men through his ability to design, to bring new and useful things into being, Dean Hollister urged a revision of the teaching of engineering that would do away with routine, pedestrian, mind-dulling methods of instruction. "Engineers should be taught from the first day that in actual practice there is no one right answer to a problem in creative design, rather that there are many good and satisfactory answers. The problem method which is now widely used and which is based upon the premise that there is only one correct answer kills initiative and imagination."

Professor Carl Muhlenbruch of Northwestern University urged his colleagues to place more stress on real pioneering. "If the colleges are to turn out more Ketterings and Wilsons, industry must help them by granting engineers greater freedom in their methods used to deliver the goods and in expanding their horizons. You can't force the engineer into a pattern or mold and then expect his creative imagination to perform miracles."

John D. Leith, associate dean at Lehigh University, called upon teachers of English to evaluate the freshman engineering student as a human person who needs to be given the opportunity to be creative. "Nowhere in the present freshman engineering curriculum is the student given the opportunity to prove that he can create except in his English course; consequently in this course the creative instinct should not be smothered by grammar and pedantic analyses of Seventeenth Century poetry."

Pemberton Johnson of Educational Testing Service said that we need tests of a man's scale of values—what importance he puts on working with other people, working with things, working with ideas, and living as a free person under a representative form of government. Intelligence tests alone tell just a piece of the story. They don't show how well a man can cooperate, how well he will do in his day-to-day job, how much he will look ahead and plan, nor his initiative and thinking



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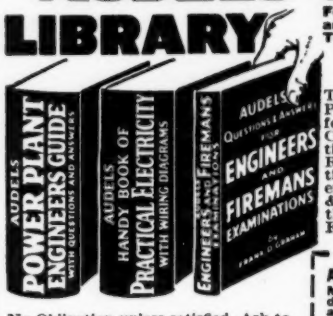

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BOOKS

1—Fuels and Combustion Handbook

ALLEN J. JOHNSON, EDITOR AND GEORGE H. AUTH, ASSOCIATE EDITOR

915 pages Price $12.50

The objective of this practical handbook is to bring together for ready reference representative factual material on fuels and combustion. Much of this information heretofore had to be searched for in pamphlets and articles scattered throughout the trade press and in publications of government bureaus and engineering societies.

More than 450 major references were used by the editors in compiling the handbook. It is estimated that 50 per cent of the material is less than five years old and over 80 per cent less than ten years old. The scope is sufficiently broad to interest fuel technicians, engineers and operating men.

The handbook is characterized by an usually large number of tables of data and by the extensive use of alignment charts for rapid computations. The nomograph method of computing heat balances has been presented in quite some detail.

There are eight sections in the handbook, covering solid fuels, liquid and gaseous fuels, combustion, fuel selection, coal preparation, fuel-handling methods, heat transfer and steam generation, and test procedures. Many recent developments in the broad field of combustion are discussed, including those associated with synthetic fuels, the heat pump, gas turbines, and spreader stokers. One very interesting chapter is entitled "Factors Involved in the Selection and Purchase of Fuel."

2—Radiation Monitoring in Atomic Defense

BY D. E. GRAY AND J. H. MARTENS

122 pages Price $2.00

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3—Steam and Gas Turbines

BY B. G. A. SKROTSKI AND W. A. VOPAT

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As might be expected from the relative use and state of development of the two types of prime movers, about 80 per cent of the text is given over to steam turbines and 20 per cent to gas turbines.

Intended primarily for operating engineers, the book is informative to anyone in the power field and might well be employed as a reference text for students, despite the absence of problems.

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Under gas turbines, descriptions of the simple cycle and closed cycles include a discussion of means for increasing efficiency through intercooling, reheating, etc. The same approach to the subject is employed as in the preceding chapters in steam turbines.

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BY SAMUEL GLASSTONE

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Following a request of the American Textbook Publishers Institute for a comprehensive sourcebook on atomic energy this book was prepared by Dr. Samuel Glasstone at the instance of the Atomic Energy Commission. It brings together important facts about the past history, present status and possible future of atomic science. While the work has been termed a "primer" on the whole subject of atomic science, the very complexity of the topics under discussion makes for some difficulty in reading and comprehension. On the whole it is written in language as simple as is compatible with the subject.

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An idea of the scope of the book may be had from the following representative chapter titles: Constituents of the Atom, Natural Radioactivity, Nuclear Radiations, Isotopes, Nuclear Transmutation and Artificial Radioactivity, The Neutron, Nuclear Fission, The Utilization of Nuclear Energy, The Uses of Isotopes, Cosmic Rays and Mesons, and Radiation Protection and Health Physics.

5—Steam Plant Operation Second Edition

BY EVERETT B. WOODRUFF AND H. B. LAMMERS

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In the present edition the text has been largely rewritten to bring it up to date as regards present designs of equipment and current practice.

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